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INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING THE SEASON 1919.

The season 1919, which was characterised by an unusual period of drought, was of exceptional interest from the point of view of insect distribution, and, given a complete set of records, might have taught us much regarding the effect of extreme conditions on the behaviour of our insect pests. Thanks to the energetic efforts of the Secretary to the Surma Branch a goodly number of reports were received from that district during the latter part of the season, but only one or two forms were received from the districts of North Bengal, and reports from Assam were received irregularly, while none were received from the north bank of the Brahmaputra. We regard these reports as of such interest and importance that we propose to continue in our endeavours to arouse interest in the matter. To this end the report forms have been bound up in books of 24—a suggestion made by interested planters in the Surma Valley. It will thus be possible for each planter to keep copies of the reports, and to obtain for his own use a continuous record of the behaviour of the insect pests on his estate. In many cases we have received one or two very full reports from one garden, and then no more. This would seem to show that many who are prepared to help do not receive forms regularly. If such will communicate with the Officer-in-charge at Tocklai he will be pleased to send to each a book of forms, and to register his name to receive a book regularly each year.

The reports received during 1918 are of considerable interest, and show that the general tendency of the exceptionally dry year was to bring about considerable decrease in the damage done by caterpillar pests, and, on the whole, to augment the damage done by the sucking insects. Most of our caterpillar pests feed on a variety of plants, and can adapt themselves to considerable variation in the nature of their food supply. Nearly

all these pests are most successfully dealt with during the resting period of the chrysalis stage, and the prolonged desiccation of an exceptional drought has a considerable effect on their numbers owing to its interference with the proper course of pupation. The sucking insects, however, are more specialised in their feeding habits, and owing to their incomplete metamorphosis do not demand special sets of conditions at different periods of their life histories for successful development. The nature of the food supply thus becomes of more relative importance in control, and the effect of the drought on these pests is in all places modified by existing conditions of soil, cultivation, drainage, etc. Thus, while caterpillar pests were universally of less importance during 1918, we find that the mosquito, green fly, red spider, and pink mite are recorded from some parts as having been less than usual, from other places as having been worse than usual. Were the climate the only controlling factor these differences should not occur, and the sucking insects should be universally better or worse, like the caterpillars, in an exceptional year like the last. They were, on the whole, as stated above, worse, but this was by no means general, and the object of asking for the reports is to correlate the instances and endeavour to elicit the other factors influencing the matter. Greenfly, for instance, was reported as being worse than usual from two places in Assam and two in North Cachar. The former two places are gardens in which a good deal has been cut out of the bushes of late years, the latter are subject to hail almost annually. There may be some connection, but owing to the incompleteness of the record the matter cannot at present be carried any further.

The records of the treatment of tea mosquito with insecticides are of interest. In nearly all cases where the damage done was slight the managers regard the treatment as successful to some extent, but where mosquito was severe no sign of improvement could be noticed. An encouraging record is the reported freedom of plots, treated with potash some three years ago, from serious attack by mosquito. The records of borer attack give

INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING SEASON 1919. 29

point to a suggestion for dealing with them at a time when greater results may be expected from the treatment.

Appended are diagrams, more or less complete, showing the nature and extent of insect damage on gardens from six districts :—

I.—LAKHIMPUR.

	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Orange beetle ...								
Bunch caterpillar ...								
Red slug ...								
Gelatine grub ...								
Sandwich caterpillar								
Tea mosquito ...								
Red spider ...								
Bark-eating borer ...								

II.—SIBSAGAR.

	March.	April.	May.	June.	July.	Aug.	Sept.
Orange beetle ...							
Faggot worm ...							
Bark-eating borer ...							
Green fly ...							
Red spider ...							
Limpet caterpillar ...							
Looper							

30 INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING SEASON 1919.

III.—NORTH CACHAR.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Red borer ...												
Bag worm ...												
Bark-eating borer												
Tea mosquito ...												
Thrips ...												
Termites ...												
Red spider ...												
Pink mite ...												
Crickets ...												
Green fly ...												

IV.—LUKHIPUR.

	Earlier.	Sept.	Oct.	Nov.	Dec.
Orange beetle ...					
Red borer ...					
Faggot worm ...					
Gelatine grub ...					
Looper ...					
Tea mosquito ...					
White ants ...					
Tortrix ...					

INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING SEASON 1919. 31

V.—CHUTLA BHEEL.

	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bunch caterpillar												
Faggot worm ...												
Bag worm ...												
Sandwich caterpillar ...												
Tea mosquito ...												
Red spider ...												

VI.—HAILAKANDY.

	August.	September.	October.	November.
Orange beetle ...				
Gelatine grub ...				
Bark-eating borer ...				
Tea mosquito ...				
Thrips ...				
Termites ...				
Red spider ...				

Very slight ...

Slight ..

Serious ...

Very serious ...

BUNCH CATERPILLAR.

(*Andraca bipunctata*—Wlk.)

These insects are reported from both the Brahmaputra and Surma Valleys, being in evidence during February to May and again during October. They are everywhere reported as having been much less numerous than during 1918. Collection of the clusters is everywhere reported as an efficient means of control.

SANDWICH CATERPILLAR.

(*Agriophora rhombota*—Meyr.)

This pest occurred in the Lakhimpur district of Assam, but is not reported from other districts. The damage done was not serious, and collection of the insects sufficed to keep them down. They were present in smaller numbers than in previous years. In Cachar and Sylhet they were present in small numbers, but on one garden in Sylhet they were present in considerable numbers in the latter half of the season.

LOOPER CATERPILLAR.

(*Biston suppressaria*—Guen.)

This pest is reported from Assam and Cachar, but nowhere attained to serious proportions.

RED SLUG.

(*Heterusia magnifica*—Butl.)

This pest is reported only from the Assam Valley, and there only from the Lakhimpur district, where caterpillars were found in the tea in small numbers in July and October, being less in evidence than during 1918.

FAGGOT AND BAG WORMS.

(*Clania* spp.)

These are reported from the Brahmaputra and Surma Valleys, and from the Duars, and appear to have been noticed, in small numbers, at one place or another, throughout the year. Their numbers were, on the whole, slightly less than in the previous year.

LIMPET CATERPILLAR.

(*Acanthopsyche rei*—Watt.)

Odd specimens recorded from Sibsagar and Sylhet. This insect nowhere attained the status of a pest.

GELATINE GRUB.

(*Belippa* spp.)

In the Lakhimpur district of the Brahmaputra Valley these insects were most conspicuous in July. Reports from the Surma Valley indicate that an attack was also noticed which commenced at the middle of October and continued into November. In both districts the attack was less serious than in the previous season.

NETTLE GRUB.

(*Thousea cervina*—Moore.)

One garden in the Happy Valley district of Cachar reports the occurrence of these insects in early November. The damage done to the tea was negligible.

RED BORER.

(*Zeuzera coffeae*—Nietn.)

This pest is reported from all districts, being generally said to have attacked a few bushes here and there, but from one garden in North Cachar it is reported as being serious. This garden is in a district subject to hail and very badly affected by borers of all kinds.

An interesting fact observable in these records is that the pest was noticed by planters to be particularly in evidence at two periods of the year, namely, in March to April and in August to September. It has always been supposed that there is one brood of these moths per year, and that the caterpillar spent the greater part of a year inside the stem of a bush. Borers found in the field at Tocklai in February and March have always become adult in March and April, but there is an adult specimen in the Kanny Koory collection recorded by Mr. Antram as having been captured in December. It seems highly probable, therefore, that there are

34 INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING SEASON 1919.

two broods of these insects in the year, and that during the early part of the pruning period such caterpillars as are present are almost ready to pupate (we know that they are generally full-grown). If this be the case cutting out the dead branches will not be of much avail unless they are burnt, as pupation and emergence can take place while the prunings are lying on the ground. The most logical method of dealing with the pest would appear to be to send one or two intelligent men round the garden towards the end of August or in early September, with a pruning knife and a basket. Bored shoots are beginning to die and show up conspicuously in the plucking tea, and could be easily cut out, taken to the factory, and burnt, thus ensuring the destruction of the insects.

BARK-EATING BORER.

(*Arbela dea*—Swinh.)

The depredations of these pests seem to be gradually lessening year by year, probably owing to the fact that more careful attention to pruning is having its effect. The insect is reported from all districts, but in only one or two cases, in Cachar, is the damage reported as of serious moment, and in those cases it was less than in the previous year.

ORANGE BEETLE.

(*Diapromorpha melanopus*—Lacord.)

This pest, which is reported from Assam, Cachar, and Sylhet, is distributed more or less universally throughout the tea area, being generally slight, but locally serious, more especially in cases where there is much jungle about, and on cut down tea, where, owing to the smaller number of shoots on the bush during the early part of the season, its effects are more noticeable. The reports for 1919 show, that both in the Brahmaputra and Surma Valleys a climax was reached at two periods during the season, the first being from April to June, the second in September, but odd individuals were to be seen throughout the season. On the whole, this pest was distinctly worse than usual, though nowhere did it attain the rank of a major pest.

TEA MOSQUITO.

(Helopeltis theivora—Waterh.)

The season 1919 was marked by an exceedingly serious attack of *Helopeltis* in Cachar and Sylhet, while in Assam and the Duars the damage done was less than usual. This distribution is correlated to some extent with the duration and severity of the drought experienced in all districts during that season. In the Duars the pest behaved according to precedent, and hot dry weather resulted in a comparatively mild attack. In Nowgong, again, where the pest was exceptionally bad during the wet season of 1918, the season 1919 was marked by comparative freedom from attack. In Cachar and Sylhet, however, where the drought was more prolonged, and where, in many places, the system of drainage considered necessary is such that unless the drains are "bundled up" the bushes suffer from drought at the end of every season, the bushes seem to have had no power of resisting attack at all, and reports of serious damage are the result. In the Surma Valley it is interesting to note that the area particularly badly affected did not include North Cachar and North Sylhet.

On several gardens in the Surma Valley experiments were carried out some three years ago with potash manures. In certain cases, where no result was obtained at the time, managers have reported this year that those treated areas were more free from mosquito than the surrounding areas. This fact, taken in conjunction with the results recorded in Part IV of the Quarterly Journal for 1919, is significant.

GREEN FLY.

(Empoasca flarescens—Dist.)

This pest was, on the whole, less serious in the Brahmaputra Valley than in 1918, but in one or two instances, notably in Sibsagar and Lakhimpur, the attack was of exceptional severity on an estate, while the neighbouring gardens report the pest to have been less serious than usual. Reports from North Sylhet and North Cachar report green fly to have been more prevalent

36 INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING SEASON 1919.

than during the previous year, while in the Nagrakata district of the Duars the pest was also more in evidence than in 1918.

THRIPS.

(*Physothrips setiventris*—Bagn.)

Reported as having been seen in North Cachar in June and July and in Hailakandy in September.

CRICKETS.

(*Brachytrypes achatinus*—Stoll.)

These pests receive remarkably little mention in the reports, but are reported as having been very serious in nurseries, young extensions, and cut back tea in North Cachar. They were, as a matter of fact, particularly in evidence in 1919.

TERMITES.

As was to be expected in such a dry year, these pests were worse than usual in Cachar and Sylhet, but in Assam, where the attacks of the insect do not attain such serious proportions as in the Surma Valley, no particular increase in severity appears to have been observed. The reports indicate the value of thullying and good deep hoeing in reducing the extent of attack.

RED SPIDER.

(*Tetranychus bioculatus*—W.-M.)

Red Spider was generally rather more serious than in 1918 during the early part of the year, and a second attack beginning about September was more general than usual. In several instances the benefit of shade trees was noticed, the action of these being probably due to their having assisted in the upward movement of water through the dry soils. Lime-sulphur, lime and fresh cowdung, sulphur, and cowdung, sulphur, and mud, are all reported to have been used successfully as checks.

PINK MITE.

(*Phytoptus theae*—Watt.)

More serious than in the previous year in North Cachar during May and June.

E. A. A.

No. 1.

Under surface.



Leaf with Brown blot Under surface (*Glomerella cingulata* Stomen.) S. & V. S.

No. 2.

Upper surface.



Leaf with Brown blight Under surface (*Glomerella cingulata* Stonem.) S. & V. S.

THE FUNGUS DISEASES OF THE TEA LEAF

BY

A. C. TUNSTALL, B. SC.

AND

S. C. BOSE.

(Continued from 1920, Part I, page 25.)

Brown blight.—*Glomerella cingulata* (Stonem.) S. & v. S.
= *Colletotrichum Camelliae*, Mass.

Brown blight attacks the leaves and green stems of the tea plant. Brown blight is sometimes very serious indeed and the loss in crop due to a severe attack is very considerable. It is more commonly serious on unpruned than pruned tea and is frequently the cause of disappointing yields especially when weather conditions are unfavourable, either too dry or too wet. The writers would urge planters to study this disease carefully, as if it really gets a hold on a block of tea it is exceedingly difficult to check. The portions attacked by the fungus die, forming patches yellowish to chocolate brown above and light brown below. The edges of these patches are sharply defined and commonly marked with a delicate concentric zonation consisting of narrow lines and darker bands. Several spots may coalesce to form one large irregular patch. Minute black dots or pustules (the acervuli of the fungus) are seen arranged in concentric lines on both sides. On some of these spots may be seen milky or pinkish drops. These are masses of spores or seeds of the fungus. This disease

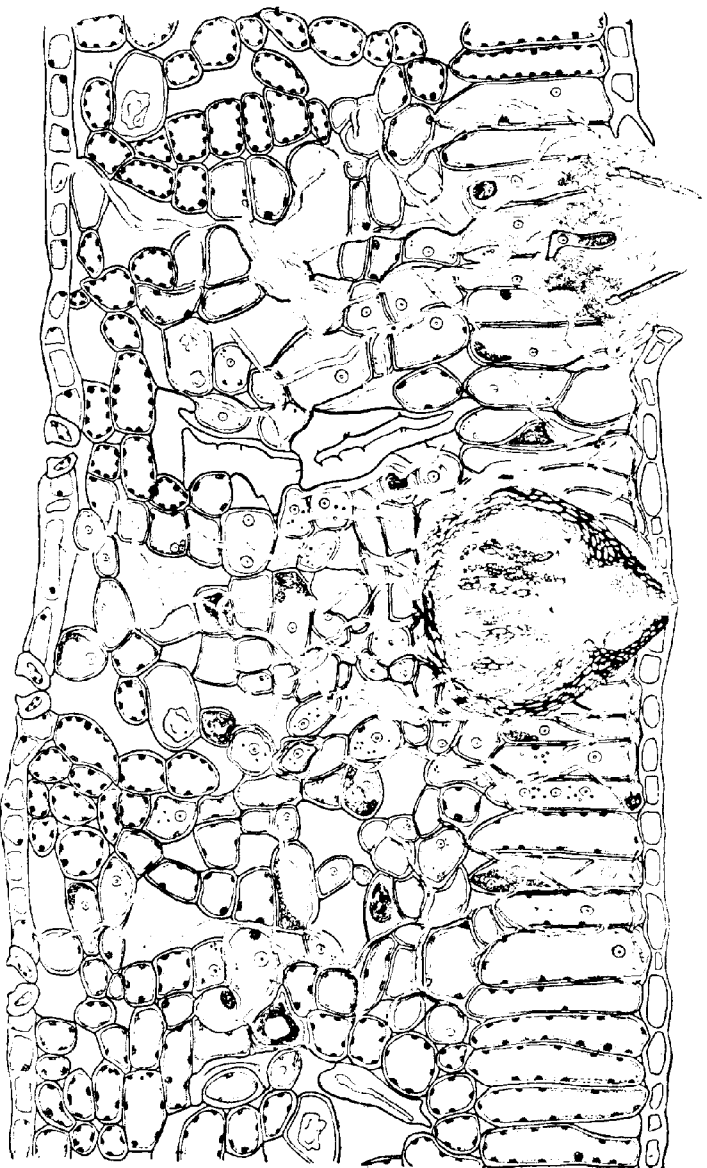
is often confused with grey blight which it resembles. The black dots on the diseased patches due to grey blight are, as a rule, much larger than those of brown blight, but sometimes it is difficult to distinguish these diseases without a microscope. Examined by a pocket lens these dots will be seen as crater-like openings, some of which are surrounded by deep brownish-black hairs or papillae. A cross section of the diseased spot when examined under the microscope will show that the pustules are formed beneath the skin and later push their way through by the development of a mass of mycelium covered with cone-shaped erect hyphae or filaments. The end of each hypha or filament swells slightly and later is separated from the rest by a wall. The detached portions correspond to the seeds of higher plants and are called spores. This particular kind of spore is called a conidiospore. One or more conidiospores are produced from a single hypha. These spores have a gelatinous coat and they often stick together and emerge as a milky or pinkish exudation. The spores stick to insects, like red spider or green fly, cattle, the clothing of coolies, etc., and are thus distributed. They are oblong with their ends rounded, colourless, one-celled, rarely two-celled and measure 12.5--20 by 5--8 μ (1000ths of a millimeter). This is the imperfect stage of the fungus and was for a long time the only known fruiting stage. It was known as *Colletotrichum* Sp. and *Gloeosporium* Sp. When the blackish hairs mentioned above were present the fungus was called *Colletotrichum* Sp. When no hairs were found it was called *Gloeosporium* Sp. The fungus however seems to be identical. There are species of *Gloeosporium* found on tea but they have smaller spores. There are also various strains of the brown blight fungus, some of which develop few hairs.

This form of fructification is found throughout the year.

At a later stage the surface of the spot bearing the conidial form of the fungus becomes light grey and covered with black dots. If a section be cut across such a spot and examined under a microscope it will be seen that these black dots are the crater-like openings of spherical receptacles called perithecia. The



A photograph of a leaf with Brown blight. (The spores are more distinct than in the coloured plates).



A diagram showing the effect of Brown blight on the same section of leaf illustrated in the first part of this series of articles. Note the two forms of fructification of the fungus and the destructive effect of the fungus mycelium on the tissues of the leaf.

perithecia are never surrounded by any dark hair like the acervuli of the conidial form. The perithecia, produced singly or in groups, remain embedded in the tissue with their mouths only projecting. The perithecia are nearly spherical, and occasionally with short beaks. They are black and carbonaceous and measure 110—160 by 115—145 μ . They contain a large number of club shaped sacs (asci) each of which contain 8 spores. These spores are called ascospores. The asci measure 55—74 by 10—13 μ . The ascospores are one-celled, colourless, slightly tapering towards their ends and usually slightly curved. They are arranged in two rows within the ascus and measure 12.5—18 by 3.5—5 μ . The interior of the beak of the perithecia is covered with hairs. These hairs have an important function as they regulate the escape of the spores.

This form of fructification may be found throughout the year, but it is most common during January to July, *i.e.*, during the cold weather and early rains.

The fungus infects the leaf when it is quite young. A tiny tube from the spore enters the skin and the contents of the spore pass into one of the cells of the skin and there remains dormant until the leaf is well stored with suitable food substances. The blight first appears on the upper surface of the leaf as a yellowish brown spot. As the spot gets older the tissue of the leaf dies, becoming dry and brittle. The central part of the spot sometimes ruptures and falls out, leaving a hole in the leaf. The disease is found more or less throughout the year, but it is more common during the rains, when the fungus attacks both leaves and green stems and the stems become dry and black and are easily broken. Both the forms of fruit bodies of the fungus appear also on the diseased stems.

The fungus has been grown in pure culture from both kinds of spores. It grows well in jelly made with either maize meal, rice meal, cane sugar, and standard dextrose.

In culture the conidiospores on germination sometimes divide into two cells by a cross wall. They germinate by one or a couple of thin hair-like tubes or filaments arising from near the

ends. The filaments give out lateral branches and in some cases give rise at their tips or in their length to black bodies by the subdivision of a portion of the filaments. These spore-like bodies are formed within 3—5 days after inoculation and send out new filaments in some cases, while still attached.

In culture the mycelium is at first colourless, later a portion assumes a dark colour with many divisions, filled with numerous bright little globules. The conidiospores are at first produced singly at the tips of lateral branches. They take 2—4 days to develop and as soon as they are completely formed, fall off. Black stromata are formed from 4—6 days, from the germination of the original spore from which the conidiospores are exuded in milky or pinkish drops. Whenever the black hairs mentioned above are present they are produced in abundance, in 7—9 days. They are either scattered or surround the stromata. They are deep brown, more or less curved, 2—3 celled.

The formation of perithecia does not take place in culture until considerably later.

In culture the ascospores on germination sometimes divide into two cells by a cross wall. They germinate within 2 days by giving out one or two filaments from either or both ends. The filaments give out lateral branches, at the tips of which conidiospores are produced within 4—5 days. The ascospores germinate readily, sometimes even inside the perithecium, and produce conidiospores. The perithecia are formed in cultures obtained from ascospores sooner than those obtained from conidiospores. They form within 6—8 days and mature within 12—30 days.

The characters of the mycelium are similar to those observed in mycelium from the conidial stage.

The perithecia are either produced singly or several are grouped within a single carbonaceous stroma.

Infection of sterilised leaves and green stems took place within 2 days, and in 11 days acervuli were formed in concentric zones. The perithecia under ordinary circumstances take a long time to develop.



Photo-micrograph of brown blight spot.

Inoculation of healthy living shoots gave the following results :—

			Per cent. of total leaves found to be infected from 42—122 days after spraying on a water suspension of the spores.
Bud leaves	...	...	32 %
Young leaves	...	...	55 %
Old leaves	...	...	20 %
Green stem	...	...	<i>Nil.</i>
Old stem	...	...	<i>Nil.</i>
Check	...	...	<i>Nil.</i>

In the experiment under notice before 44 days no obvious signs of infection were noticeable to the naked eye.

The method adopted for inoculating the shoots was as follows. The shoots were first thoroughly washed with water and then sprayed with conidiospores suspended in sterile water. The shoots were then covered with a muslin cloth bag. These results do not mean that the blight will not develop sooner than 44 days, but that on the particular experiment the plants used were not in suitable condition for the development of the fungus before that period had elapsed. In some cases it is probable that the fungus develops within a fortnight. It is very variable.

The fungus may attack any tea leaf, but if the plant is in vigorous health it does not develop.

Experiments were made to determine the longevity of spores in the following manner :—

One-half of the diseased leaves were desiccated by putting them in test tubes without plugs which were kept in a desiccator for 2 days. They were then plugged with cotton wool and sealed with paraffin wax. The other half were plugged without

desiccation. Each set was divided up into groups which were stored under different conditions.

It was found that exposure to sunshine was fatal to the fungus within a few months but under ordinary circumstances, *e.g.*, light shade and a damp atmosphere the fungus could survive the cold weather with ease when in dead material. Solitary spores have much less resistance however. From this information it is obvious that it is necessary to remove all diseased material from the tea. It would be quite safe to bury it in trenches or hoe it in provided it is covered deeply enough to avoid disturbance by subsequent light hoes.

The fungus is not confined to tea. It grows on ripe fruits and other parts of common jungle trees. It also attacks the *Albizias*, *e.g.*, Sau, Koroi trees. It is therefore impossible to eradicate it, but on most gardens the infecting material may be reduced to a great extent during the cold weather.

It will be seen that there are many serious difficulties in dealing with this disease. There is no doubt that the soil condition is a very important factor in this disease. The fungus is so common that if all the tea was susceptible to attack little would survive. What then are the particular conditions favouring the disease? At Tocklai a plot of tea including all the common types of tea was allowed to become seriously attacked with the disease. The light leafed varieties were more severely attacked than other jats including China. Light leafed varieties of tea are usually more susceptible to disease. The behaviour of China tea was exceptional. It was distinctly less susceptible to the blight. The diseased shoots were removed and the lime-sulphur solution applied immediately after. At the same time an application of Potassium nitrate was made. There was a marked diminution of the disease. Later experiments showed that Burgundy mixture was a better spray fluid than lime-sulphur solution for this disease.

The disease remains in young infected stems and from these infects the new leaves next season. Sometimes big stems die

right back. It is therefore important to cut out all diseased wood at pruning time.

THE TREATMENT OF THE DISEASE.

1. In the case of isolated bushes it is important to pluck off all diseased shoots and spray with 2 per cent. Burgundy mixture, not only the infected bush but all those adjoining it.

2. If there are signs of a serious attack developing, manure the soil at once with the following :—

1 oz. per bush Nitrate of potash forked in round the bush.

This treatment has given definite results at Tocklai. It is probable however that a mixture of :—

$\frac{3}{4}$ oz. Nitrate of potash

$\frac{3}{4}$ oz. Sulphate of potash

would do better.

Application of nitrogen alone has been found to lead to increased liability to attack.

After removing all diseased shoots, spray with 1 per cent. Burgundy mixture.

3. In the case of unpruned tea on gardens where previous experience leads one to expect an attack it is well to remove all diseased leaves and shoots and spray with 2 per cent. Burgundy mixture during the cold weather. This treatment will pay in any case whether brown blight is expected or not. It will help to check red rust and copper blight.

It should be specially noted that nothing predisposes plants to this disease so effectively as bad drainage or poor tilth due to lack of organic matter in the soil. Whenever the disease causes much damage special attention should be paid to these points.

PRUNING EXPERIMENTS ON YOUNG TEA.

In Quarterly Journal, 1918, page 129, are given the results, after one year, of cutting down young tea at heights varying from the collar up to 24" from the collar. In the table now given will be found the results of the first and second years' pluckings.

It should be carefully noted that the bushes described as collar-pruned were cut right through the collar itself, that is, through the place where stem and root join. If planting were perfect this would of course mean the ground level. Many planters, however, make a practice of planting with the collar a little below the ground level in order to avoid the error of planting with part of the root exposed. Others plant deliberately a little high, knowing that the soil will rise under cultivation. In any case it is difficult to make supervision so efficient that every bush is perfectly planted, *i.e.*, with its collar on the ground level. It is, therefore, more accurate to describe the cutting with reference to the collar than with reference to the ground level. "Ground level" also is difficult to find when bushes have been forked round.

The experiments have shown that wherever the cut be made, at any rate with a bush cut to below 6", the greater number of new shoots arise from the stem just above the collar. When the cut is made through the collar, therefore, very little or none of the best shoot-yielding region is left. For this reason a bush cut through the collar is less likely to yield shoots before it dies, than is a higher-cut bush. In these experiments the percentage of deaths from collar pruning was 8 per cent., while from cutting to 2" above the collar only 1 per cent. of the bushes died. With still higher cutting the percentage of deaths was the same or slightly less.

On the other hand if the cut is made above 2", the shoots still arise from near the collar, and the result is nearly always a snag of dead wood in the middle of the bush, and this lays the bush open to attack by white ants.

When the cut was made at 2", snags were left in very few cases, but it is possible that the cut might be made a little lower with advantage. When the cut was made just above the lowest

branch no snag was left, since the branch keeps the stump alive ; neither did any vacancies arise from the cutting. If the branch is low and not too well grown (in which case it might "run away," forming a "single-stemmer" afresh) very good bushes result from this method of cutting.

Except for the formation of a snag the bushes cut at 4" have given as good bushes as those cut lower and have averaged $\frac{1}{2}$ maund per acre more than the 2" cut bushes in the two years. This extra yield however is too dearly bought at the cost of a dangerous snag in the bush. The presence of snags has caused little trouble at Tocklai, but would certainly lead to trouble in districts where white ants are bad.

Of the cut down bushes then, those cut at 2" have proved most satisfactory.

The yields while the bush is thus being formed are low. The yield, however, can undoubtedly be greatly increased by leaving the bushes unpruned for the second year's plucking.

These experiments have not proved this point.

The year 1919 was one of serious drought and unusually unfavourable to unpruned tea.

The tea for these experiments was arranged in lines, one line for each type of pruning, and it so happens that the lines of unpruned Burma and Assam tea run along the sides of drains. The drying of the soil due to these drains intensified the effect of the drought.

The unpruned Burma and Assam tea thus gave only about 6 maunds and 4 maunds respectively instead of at least 10 maunds which had been confidently expected.

The unpruned China tea, well away from a drain but otherwise similarly treated, did give $10\frac{1}{4}$ maunds and the expectation is that the indigenous varieties would normally have given more.

The only other line along a drainside was the China which had been collar pruned and then cut to 6". This gave only half what was obtained from the Assam and Burma bushes similarly treated.

In passing it is desired to emphasise the fact that the above is not an expression of opinion contrary to the necessity of drainage. Where a line of tea is not missed to take the drain, drainside bushes must suffer, particularly on a light soil in a droughty year; but the remainder of the clearance undoubtedly gains to an extent which more than compensates for this loss.

With the bushes which were not cut down, but "cut across" at varying heights, examination of the table will show that the higher the bush is cut, the greater is the yield obtained.

The quantity of tea obtained from the bushes so treated (20 mds. per acre in the first two years, in the case of the bushes cut at 24") looks very tempting. The bushes, also, are wide. Although planted 5' x 5' square they are now actually touching. But the crop was obtained entirely from the middle of the bush, the outsides having yielded little or nothing. Further, these outsides are very weak and are attacked by red rust and brown blight. Last year (1919) in June, each bush carried an outer ring of yellowish-white leaves as a result. It is in fact very doubtful whether the present yield can be increased or even maintained from these high-cut bushes, whereas from those cut at 4" and below we may expect, eventually, wide bushes with strong outside branches from low down, and giving very high yields.

From the high-pruned bushes, also, the yields to date are higher than would be obtained from the average clearance. The bushes were planted at 3 years old from seed, and then had two years growth unpruned and unplucked. At the time of cutting across, therefore, they were already bushes of fair size.

On the other hand the yields obtained from the cut down bushes are probably little less than would have been obtained if the plants had been cut down at 3 years from seed.

The bushes cut at 6" and then at 12" have not given the yield given by those originally cut higher, nor is the bush obtained much more satisfactory in shape than that obtained by cutting at 12".

This 12" cutting has produced a very large number of bushes with a good spread from low down, and it is probable

that if now treated by the method of taking out centres, we could obtain the advantage of an early high yield, and still obtain bushes with a satisfactory frame.

The method will be tried on a larger scale at Borbhetta.

It is also possible that if systematic "cutting out-of-centres" were practised on the bushes originally cut at 18" and 24" respectively, these also could be made to form good frames; but at present the great majority of these bushes look as if only collar pruning could produce a satisfactory bush.

Plot.	PRUNING.		YIELD.		Calculated as maunds puca tea per acre.	
	1917.	1918.	1918.	1919.	Total in 2 years.	Mean total in 2 years.
Assam	Cut across at 24" ...	4" new wood...	8.23	12.17	20.40	20.69
Burma	Ditto ...	Ditto ...	8.44	12.54	20.98	
Assam	Cut across at 18" ...	4" new wood...	9.54	9.57	19.11	17.96
China	Ditto ...	Ditto ...	8.57	8.42	16.99	
Burma	Ditto ...	Ditto ...	8.27	9.50	17.77	
Assam	Cut across at 12" ...	4" new wood...	6.87	8.67	15.54	15.14
China	Ditto ...	Ditto ...	7.93	7.83	15.76	
Burma	Ditto ...	Ditto ...	5.61	8.51	14.12	
Assam	Collar pruned ...	Unpruned ...	2.63	4.18°	6.81°	12.78 +
China	Ditto ...	Ditto ...	2.55	10.23	12.78	
Burma	Ditto ...	Ditto ...	2.13	6.07°	8.20°	
Burma	Cut down to 6' ...	6" new wood...	4.86	7.81	12.67	12.67
Assam	Cut down to 4' ...	6" new wood...	4.76	5.62	10.38	10.22
Burma	Ditto ...	Ditto ...	4.36	5.71	10.07	
Assam	Cut down to 2' ...	6" new wood...	4.15	4.76	8.91	9.57
China	Ditto ...	Ditto ...	5.37	4.79	10.16	
Burma	Ditto ...	Ditto ...	5.17	5.02	10.19	
Assam	Cut down to lowest branch.	6" new wood..	4.52	5.17	9.69	9.70
Burma	Ditto ...	Ditto ...	4.56	5.14	9.70	
Assam	Collar pruned ...	6" new wood...	2.31	4.26	6.57	7.24
China	Ditto ...	Ditto ...	2.48	2.75°	5.23°	
Burma	Ditto ...	Ditto ...	2.62	5.22	7.84	

° Drainside bushes.

† Omitting drainside bushes.

H. R. C.

EXPERIMENTS ON MANURING OF GREEN CROPS.

In Quarterly Journal, 1918, Part IV, page 87, are given the results of manuring green crops on five different soils. The results on Borbhetta soil generally resembled those on three of the other soils, the fifth (Gatoonga) behaving in an exceptional manner. The Borbhetta soil is therefore likely to give results of fairly general application.

In 1919 the plots at Borbhetta manured in 1918 were again cropped in order to determine the residual effects of the manures.

1919 was a dry year unfavourable to the growth of big green crops. The first crop, growing from early June to the middle of July, was poor : and after removal of this crop, the same beds were again sown early in August and weighed in the middle of September. This crop was no better.

Germination, however, was splendid and all beds contained the same number of plants. The poor crop was due to the poor development of the plants and not to absence of plants from death or failure to germinate. Results are therefore comparable.

The results calculated to tons of green matter per acre are given in the following table.

The figure for 1919 crop is the sum of the two crops obtained in that year :—

Manuring.				Crop in tons per acre.	
				1918	1919
Check plots	...	...	.....	2.75	1.58
				2.62	1.05
				3.12	2.27
Slaked lime	...	...	800 lbs.	2.05	2.07
				2.45	2.65
Crushed limestone	...	...	1,200 lbs.	2.79	2.29

Manuring.				Crop in tons per acre.	
				1918	1919
Slaked lime	...	...	800 lbs.	3.16	2.77
Sulphate of ammonia	...	...	150 lbs.	2.95	1.71
				3.05	2.24
Crushed limestone	...	...	1,200 lbs.	...	...
Sulphate of ammonia	...	...	150 lbs.	3.16	3.45
Carbonate of magnesia	...	...	900 lbs.	3.34	2.88
Sulphate of ammonia	...	...	150 lbs.	(1.68) 3.34	(1.32) 2.79
				3.34	2.70
Slaked lime	...	...	800 lbs.	3.07	3.57
Sulphate of ammonia	...	...	150 lbs.	3.53	3.70
Sulphate of potash	...	...	75 lbs.	3.17	2.48
					3.25
Slaked lime	...	...	800 lbs.	...	...
Sulphate of ammonia	...	...	150 lbs.	0.74	2.25
SULPHATE OF POTASH	...	...	8,200 lbs.		
Crushed limestone	...	...	1,200 lbs.	0.32	2.85
Sulphate of ammonia	...	...	150 lbs.	0.36	3.23
SULPHATE OF POTASH	...	...	8,200 lbs.	0.40	3.62
Slaked lime	...	...	800 lbs.	2.66	2.26
Nitrate of potash	...	...	50 lbs.	2.73	2.85
				2.70	2.56
Slaked lime	...	...	800 lbs.	...	...
NITRATE OF POTASH	...	...	2,500 lbs.	2.64	5.06
Slaked lime	...	...	800 lbs.	3.68	2.67
Sulphate of ammonia	...	...	150 lbs.	4.22	2.50
Superphosphate	...	...	150 lbs.	4.76	2.33
Crushed limestone	...	...	1,200 lbs.	...	...
Sulphate of ammonia	...	...	150 lbs.	4.26	3.88
Superphosphate	...	...	150 lbs.		
Slaked lime	...	...	800 lbs.	3.41	4.21
Sulphate of ammonia	...	...	150 lbs.	4.00	4.14
SUPERPHOSPHATE	...	...	8,200 lbs.	4.78	4.36
Crushed limestone	...	...	1,200 lbs.	...	...
Sulphate of ammonia	...	...	150 lbs.	3.97	7.6
SUPERPHOSPHATE	...	...	8,200 lbs.		

These results show how very greatly the soil varies from plot to plot. The variation usually depends upon the depth of surface soil.

Where a low spot has been raised by dragging surface soil over it, fertility is increased.

Where a deeper hole has been filled up with subsoil, fertility is decreased.

Where a high place has been levelled by throwing surface soil from it, fertility is decreased.

Infertility of the subsoil is a marked characteristic of Borbhetta soil, and the surface soil averages about 6" only, the depth reached by the roots of the grass jungle.

With phosphatic manures the good effect is always great enough to show an increase over the best unmanured plot, although the manure may have been applied to a plot originally the worst of the series. It appears probable that the phosphate acts by removing the cause of the infertility and not by merely supplying plant-food. That superphosphate in 1918 gave a large increase of crop on Leesh River soil containing total phosphoric acid 0.25% and available phosphoric acid 0.08% (quantities largely in excess of the food requirement of any plant) indicate that here the effect must be due to some secondary action.

Similarly it is possible that the bad effects produced by very large doses of potash salts may be due to liberation from the soil of increased quantities of the toxic substance rather than to actual concentration of potash salt in the soil.

The intensity of both the bad effects of large doses of potash, and of the good effect of superphosphate, varied greatly on different soils; and on one soil (Gatoonga) the good effect of superphosphate was very slight, while the large dose of potash gave no bad effect but an actual increase in crop.

If it can be shown that the original infertility is due to soluble compounds of aluminium or iron, the above results can be explained.

Experiments now in progress in the laboratory may throw some light on the subject.

On such patchy soil it is clear that results from one or two plots only will not yield averages sufficiently accurate to justify any dependence on the amount of the effect of any manure ; but the direction of the effect of each particular manure can be seen and is discussed separately below.

Effect of Lime :—

	Crop in tons per acre.	
	1918.	1919.
Average of slaked lime plots ...	2.25	2.36
Crushed limestone plot ...	2.78	2.27
Average of check plots ...	2.83	1.63

The use of slaked lime or crushed limestone resulted in a decrease in crop in the first year. The decrease in crop from the use of crushed limestone appears to be less than from slaked lime. There was, however, only a single plot treated with crushed limestone alone, and this was next to a check plot yielding 3.12 tons in the first year, so that it is probable that the bad effect of slaked lime and crushed limestone were about equal.

The application of lime in any form produces a profound modification in the bacterial population of the soil which often leads to an initial lowering of fertility. Chemical changes leading to a preliminary lowering of fertility may also occur.

Since the seed was sown immediately after the application of lime, this initial lowering of fertility would be expected to show up strongly.

By the second year these limed plots had so much improved that an increase in crop over the check plots was obtained.

Since all three plots give results in the same direction we may accept it as a fact that at Borbhetta the soil needs liming, but that there will be an initial lowering of fertility immediately after application.

Such an effect has frequently been observed with tea, particularly on soils containing much silt, many of which occur in the Jorehat district.

In these experiments crushed limestone has done better than slaked lime as is shown in the following table :—

Other Manure.	Average total crop (tons per acre) obtained in two years :	
	with slaked lime.	with crushed limestone.
<i>Nil</i>	4.62	5.08
Sulphate of ammonia ...	5.28	6.62
Sulphate of ammonia Sulphate of potash ... (large dressing)	2.99	3.61
Sulphate of ammonia Superphosphate ... (large dressing)	8.32	11.57
Sulphate of ammonia Superphosphate ... (small dressing)	7.25	8.14

The comparison is based only on single plots or in some cases two plots, and the results must therefore be accepted with a certain amount of reserve. However since all the differences tend in the same direction, it is probable that crushed limestone does suit this soil better than slaked lime.

Effect of Nitrogen :—While any plant hoed into the soil would increase the content of organic matter, we choose a leguminous plant as green manure because it is able to obtain its nitrogen from the atmosphere, and thus provide the soil, free of cost to us, with an amount of nitrogen which would have cost an average per acre of about Rs. 20 or more at present prices.

In a soil rich in available nitrogen a leguminous plant takes a greater part of its nitrogen requirement from the soil and less from the air.

It is, therefore, not sound to use a nitrogenous manure for the purpose of growing a green crop, except in those exceptional cases where it is absolutely necessary in order to obtain a respectable weight of organic matter. Generally speaking, however, mineral manures alone will suffice to grow splendid crops.

In the experiments under consideration the sum of the increases in crop during the two years following an application of 30 lbs. nitrogen per acre amount to about one ton of green stuff which gives to the soil about 8 lbs. nitrogen only. The value of the extra ton of organic matter is difficult to estimate, but it is certainly only a very small fraction of the price paid for the sulphate of ammonia which produced it.

That manuring of green crops with nitrogenous manures will generally show a similar loss may be taken as a general principle, whether the nitrogen is provided as chemical manure, oilcake, animal meal, or other such fertilizers. Cattle manure however in light dressings is occasionally found to give results out of all proportion to its mere content of nitrogen and phosphoric acid.

Effect of Potash :—

Manure.				Mean crop (tons per acre).	
				1918	1919
Lime	800 lbs.	3.09	2.69
Sulphate of ammonia	...	...	150 lbs.
Lime	800 lbs.	3.24	3.26
Sulphate of ammonia	...	...	100 lbs.
Sulphate of potash	...	...	75 lbs.
Lime	800 lbs.	0.49	2.93
Sulphate of ammonia	...	...	150 lbs.
Sulphate of potash	...	...	8,200 lbs.
Lime	800 lbs.	2.66	2.88
Sulphate of ammonia	...	...	150 lbs.
Nitrate of potash	...	...	50 lbs.
Lime	800 lbs.	2.64	3.04
Sulphate of ammonia	...	...	150 lbs.
Nitrate of potash	...	...	2,500 lbs.

The heavy dressing of sulphate of potash depressed the yield so much during the first year that it is clear that it was acting as a plant poison. In the second year this poisonous

effect had disappeared, and an increase over the check plot was obtained.

The small dressing of potash appears to have produced a slight increase in fertility, but the conditions of the experiment are not sufficiently accurate for the effect of only about 16 lbs. of potash per acre to be determined with any degree of certainty.

On this soil normal crops are only obtained if some phosphatic manure is applied.

Whether potash is useful on this soil or not, would be best determined on soil that had been previously treated with a phosphatic manure; we are therefore unable to decide this point on the results of the experiments under consideration.

Effect of Phosphoric acid.—As in previous experiments phosphoric acid was found to be the main factor in producing a good green crop on this soil, and it is clear that no harm from addition even of an enormous excess need be feared.

In the first year the small dressing of 150 lbs. of superphosphate produced a slightly greater effect than 8,200 lbs. It is therefore probable that there is no need to apply larger dressings than 150 lbs. per acre.

In the second year this small dressing was still showing marked residual effects, but the plots which had received the very large dressings were producing crops very much better still, the figures being:—

Manuring.					1918	1919
Lime	800 lbs.	3.09	2.79
Sulphate of ammonia	...	...	...	150 lbs.
Lime	800 lbs.	4.23	3.29
Sulphate of ammonia	...	...	...	150 lbs.
Superphosphate	...	...	...	150 lbs.
Lime	800 lbs.	4.05	5.31
Sulphate of ammonia	...	...	...	150 lbs.
Superphosphate	...	...	...	8,200 lbs.

It appears probable that the effect of the smaller dressing of superphosphate is falling off. A further 150 lbs. would in all probability have made the yield from these plots equal to that produced by the plots which had received the enormous dressing the year before.

H. R. C.

NOTE ON THE POTASH—PHOSPHATE CONTENT OF TEA SEEDLINGS AND LEAVES.

A set of manuring experiments on tea seedlings is being carried out in the Tocklai laboratories, the object of which is to determine, if possible, the soil solution most suitable to tea plant growth.

The seedlings are germinated in sand and then planted in bottles containing pure, acid-washed sand. When the seedlings are established the cotyledons are removed and liquid manures of various strengths are added. After two or three months the plants and the unabsorbed manures will be analysed. The perfect manurial solution should contain its constituents in the same ratio after as before the experiment.

As a preliminary to those observations, the estimations of potash and phosphate were made on tea seeds and on a number of plants immediately before the addition of nutrient solution. Up to this stage all the food supplied to the plants had come from the seeds. It is a justifiable assumption that the food contained in the seeds is ideal and that the seedlings should contain phosphates and potash in ideal quantities and in perfect balance provided that the moisture content of the sand is kept normal.

Betjan seeds grown at Tocklai were germinated on 3rd December 1919. On 15th March 1920, 75 seedlings of height 2.3 inches were taken from the sand, washed and divided as follows :—

Total weight of seedlings	190.92	grams.
„ roots	29.55	„
„ stems	23.20	„
„ leaves	16.02	„
„ cotyledons	122.15	„

The analyses are given below. Figures refer to percentages :—

	Seed without shell.	Cotyledon.	Root.	Stem.	Leaf.
Moisture ...	.....	64.91	78.12	78.06	79.67
Ash in dry matter ...	2.82	2.55	5.45	4.52	7.92
Phosphoric acid in ash ...	16.42	15.15	9.35	12.55	17.90
" " in dry matter .....	.....	0.38	0.51	0.61	1.41
Potash in ash ...	55.30	41.99	29.01	46.90	52.79
" " in dry matter ...	.....	1.03	1.58	2.27	4.14
Ratio K_2O/P_2O_5 ...	3.36	2.77	3.10	3.73	2.94

The high ratio, $K_2O/P_2O_5 = 3.73$ in the stem is quite in accordance with the experience that potash manures are helpful for growing wood after the bushes have been cut back.

The distribution of potash and phosphates in the young plant is shown in the table below :—

	Root.	Stem.	Leaf.
% Total potash ...	28.26	33.44	38.30
% Total phosphoric acid ...	30.21	28.75	41.04

Other interesting ratios are :—

Ratio K_2O/P_2O_5 in seedling including cotyledons = 2.92.

Ratio K_2O/P_2O_5 in seedling excluding cotyledons = 3.03.

The figures of most interest, on account of the observations of the Entomologist (Quarterly Journal, 1919, IV, p. 119), are those connected with the leaf. Analyses were made by Bamber (Chem. and Agri. of Tea, 1893, App. III, p. VII), on leaves throughout the year. He obtained the following results :—

Month.	% Ash in dry leaf.	In Ash.		Ratio K_2O/P_2O_5
		% potash.	% phosphoric acid.	
May ...	4.69	46.06	16.67	2.76
August ...	4.58	31.07	12.00	2.50
November ..	5.07	18.67	10.70	1.75
May (old leaves) ...	5.14	14.20	10.64	1.33

As the leaves age, the variation of the ratio K_2O/P_2O_5 will be noticed. But flushing leaves have about the same Ratio throughout the season. Thus leaves plucked at Tocklai between May and November showed the following variations. The potash varied between 53.95 and 44.02% and phosphates between 14.11 and 17.48% of the ash. The maximum ratio $K_2O/P_2O_5 = 3.10$ and the minimum = 2.80. The mean ratio for the season was 2.98.

It must however be remembered that a ratio of this kind loses its significance unless the factors be within certain limits. Thus analyses of leaves from gardens subject to mosquito blight show low percentages both of phosphate and potash although the ratio is frequently the same as that given by leaves of un-attacked bushes. In the table below, the analyses of leaves from Tocklai, in which district mosquito blight has not, up to the present, done any serious damage, may be compared with those of leaves from gardens in areas subject to the blight:—

Garden.	% Ash in leaf.	In Ash.	
		% potash.	% phosphoric acid.
Tocklai E. S. ...	5.45	48.00	15.82
Koombhir ...	5.15	31.17	12.55
Washabarie ...	5.18	31.72	14.70
Ellenbarie ...	5.25	24.72	12.45

The slightly higher ash content at Tocklai is probably due to fine plucking. The figures given for Tocklai are the analyses for the season, but those of the other gardens are those at the beginning of the season. Koombhir did not suffer from blight and in November the leaves gave a Ratio $K_2O/P_2O_5 = 34.12/13.5$ showing only a slight change. Washabarie was attacked by mosquito, but did not cease plucking. At the end of October the leaves gave a ratio $K_2O/P_2O_5 = 32.99/13.05$. Ellenbarie, which was badly attacked, ceased plucking in August, the leaves then showing the ratio $K_2O/P_2O_5 = 37.6/9.9$.

These facts all support the theory that the controlling factor in mosquito attack is the percentage of phosphoric acid and potash, particularly the latter, in the leaf.

C. R. H.

NOTES ON THE TREES COMMONLY USED FOR
SHADE AND GREEN MANURE IN TEA
CULTURE, AND THEIR ALLIES.

(Continued.)

The descriptions given below have been compiled from Brandis, Roxburgh and Hooker with the exception of that of *Albizzia moluccana* and *Pithecolobium saman* which were compiled from information supplied by the Economic Botanist.

Derris robusta—Benth.—(See Plate X.)

Common names used in the tea districts :—It is sometimes called Koroi in Assam.

Description :—A fair sized deciduous tree with leaves 3-6 inches long made up of 6-18 pairs of leaflets. The leaflets are 1-2 inches long, opposite with a terminal one. They are oblong on one side and elliptic on the other. When young they have silver grey hairs on their undersides. Pinkish white flowers are produced in clusters in the early rains before the leaves appear. The pod is 1-2½ inches long and ¾ inch broad, and contains 1-5 seeds. It has a characteristic shape with a wing about ¼ inch wide.

Distribution :—It is common in Assam and the surrounding hills.

General :—This tree grows best on a sandy soil with a fairly high percentage of silt and fine sand. It is not liable to become cankered. It gives a light shade and tea does well under it. It is planted instead of Sau on a number of gardens in the Jorhat district and planters say that it does much better, principally because it does not get canker.

Pithecolobium saman—Benth.—(See Plate XI.)

Common names used in the tea districts :—It is called the Rain tree.



Drawn by K.P. Das lith.

DERRIS ROBUSTA Benth.



K.P. Daslith.

PITHECOLOBIUM SAMAN Renth

Description :—An immense rapidly growing tree with wide spreading branches. Twigs velvety. Leaves 2-4 pinnate ; leaflets oblique, ovate-oblong or almost circular, up to $1\frac{1}{2}$ inches long, shining above, downy beneath. Peduncle 4—5 inches. Flowers arranged in heads. Calyx $\frac{1}{4}$ inch pubescent (downy). Corolla about $\frac{1}{2}$ inch, yellowish, silky. Stamens 20, light crimson. Pod sessile, straight, thick margined, leathery, fleshy, glabrous, indehiscent (does not split), 6—8 inches long, $\frac{1}{2}$ to 1 inch broad, flattened or nearly cylindrical.

Distribution :—It is not a native of India, but was introduced many years ago apparently from America, where it is said to be common in the warmer regions.

General :—The tree is much too heavy for use as a shade plant in tea. As it is one of the few leguminous trees able to grow on ant hills and bustie sites, it is sometimes used for improving the soil of such areas. It is an excellent firewood tree.

The pods contain sugar and are good for cows.

NOTES.

The Effect of Drainage on Soil Acidity.—By S. D. Conner, Indiana Agricultural Experiment Station, Lafayette, Indiana, published in "Science"—N. S. Vol. XLVI, No. 1186.

"For the purpose of studying the effect of drainage on soil acidity, samples of soil were taken in October 1916, from three of the experiment fields of the Purdue Agricultural Experiment Station. These fields are located near Westport, North Vernon and Worthington. The soils of these fields are all heavy silt loam, very low in organic matter and naturally poorly drained and quite acid in reaction. All of these fields have been thoroughly tile drained from three to five years. A portion of the Westport field is undrained and there are adjacent undrained, untreated areas alongside the North Vernon and the Worthington fields.

TABLE I.

Relative acidity of drained and undrained soils.

Field and Soil Treatment.	Lbs. CaCO_3 * needed per 2,000,000 lbs. Soil.	
	Drained.	Undrained.
WESTPORT FIELD—		
Limestone	40	760
Limestone, phosphate and potash	30	360
Untreated	860	1,280
NORTH VERNON FIELD—		
Untreated	1,880	2,840
WORTHINGTON FIELD—		
Untreated	740	1,600

Table I shows the acidity of the soils as determined by the potassium nitrate method. Without entering into a dis-

* Carbonate of lime (*e.g.*, limestone).

cussion of the merits of different soil acidity methods, it may be said that on these soils, which are low in organic matter, there is no great difference in the degree of acidity shown by this method and lime water and calcium salt methods. These results are consistent enough to indicate that drainage has a material influence on the acidity of soil of this type.

Farmers often refer to wet, poorly drained land as sour. While agricultural writers have placed little or no emphasis on such a correlation, it is quite probable that soils in general will tend to become less acid when thoroughly drained, and *vice versa*, they will tend to become more acid when waterlogged and poorly aerated. In testing soil acidity at different seasons of the year the results often vary quite a little in samples from the same plots of soil. These differences cannot be attributed altogether to errors in sampling. The writer believes that at least part of the change of acidity is due to difference in aeration and moisture content of the soil at different seasons. Lipman and Waynick, in an investigation of the effect of climate on soil properties, report that Maryland soil, which shows an acid reaction in its original location, when transported to Kansas or to California becomes neutral or slightly alkaline. It is quite probable that the better drainage and aeration of the soil when placed under less humid conditions could account very largely for the changes in reaction.

Considering silica an acid-forming oxide, practically all soils except those very high in the basic reacting elements, have a potentially great capacity for developing an acid reaction.

The writer believes that the constitution of the silicates of aluminium has more to do with injurious soil acidity than any other single factor. The acidity of aluminium silicates varies both with the relative proportion of Silica to Alumina and with the amount of combined water in the silicate. The weathering and changing of soil silicates under poorly drained or well-drained conditions would undoubtedly vary the constitution of the silicates and also vary the degree of soil acidity. It is quite true that certain types of well-drained sandy soils are

acid. It is true also that a number of other factors besides drainage conditions affect soil acidity, but it is probable that the most acid soils are formed in poorly drained areas."

The above is entirely in agreement with observations made by officers of this Department.

The connection between waterlogging and soil acidity is often very noticeable in the tea districts.

While it is true that agricultural writers generally have placed little or no emphasis on such a correlation, it has been referred to frequently by this Department both in private reports and in published general notes. (See Quarterly Journal, 1919, page 115 (Terai); Quarterly Journal, 1919, page 157 (last para.); Quarterly Journal, 1920, page 15 (top of page).

Relation of certain aluminium compounds in soil to soil acidity.—Frank E. Rice (*J. Phys. Chem.*, 1916, 20, 214-227) states :—

"When a soil is shaken with a neutral salt solution, the metal part of the salt is removed by the soil and other bases are given up to the solution in exchange. The extracts are generally acid and there is much uncertainty as to whether this acidity is due to the absorption by the soil of excess of base, leaving an equivalent quantity of acid in solution, or to the presence of a hydrolysed salt.

Soils were shaken with potassium nitrate solution and the filtrates were examined. Calcium and magnesium were always found in solution; aluminium in the more acid extracts; manganese sometimes but iron never. An examination of the nitrates of calcium, magnesium, aluminium, and manganese showed that only aluminium nitrate behaved like the soil extract in being strongly acid. The conclusion is drawn that the acidity of the extract is due to the presence of a hydrolysed aluminium salt.

The infertility of acid soils is probably due to the presence of loose combinations of the weaker bases, such as alumina, and not to the presence of true acid hydrogen."

These observations agree with those made at Borbhetta.

This is a possible explanation of the fact that the addition of a further quantity of strong acid, in the form of superphosphate, to an acid soil, increases the fertility. The function of the superphosphate is probably to render insoluble some of the aluminium compounds.

(See current issue Quarterly Journal, pp. 50 & 54.)

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1920.

ADDRESS ON THE CONTROL OF THE MOSQUITO
BLIGHT OF TEA. (*HELOPELTIS THEIVORA*
WATERH.) GIVEN BY THE ENTOMOLOGIST
BEFORE THE COMMITTEE OF THE INDIAN TEA
ASSOCIATION, (LONDON).

You will ere this have seen a copy of Part IV of the Quarterly Journal of the Scientific Department for 1919, in which I have published a short note on the present state of the Mosquito Blight enquiry, which, to some extent, anticipates what I have to say to you to-day. I shall not, therefore, confine myself, as I at first intended, to giving you a short summary of the results achieved along the lines which appear to me to be the most promising from the point of view of complete control, but shall endeavour to give you as complete an idea as possible in the short space of time at my disposal of the nature of the problem we are endeavouring to solve, of the methods which have been followed in its investigation, and of the progress which has been made towards its solution.

First, a few general remarks on the question of insect control, as applied to a problem of this nature. We have an insect feeding on a plant, situated in a given environment. There are thus three factors—the insect, the plant, the environment, the mutual reactions of which culminate in a result which we estimate by the amount of damage done to the plant. Now the environment reacts both on the insect and the plant. Changes in the characteristics of the environment produce changes in the vitality of both the insect and the plant, these changes being most noticeable in extreme cases, where the insect or plant is found, in the one case, to flourish, in the other case, to die. The converse reactions of the insect and plant on their environment, so far as we know at present, are so small as to be negligible. Again, the insect reacts on the plant, as we know by the loss of crop produced, and the plant reacts on the insect, for it is the source of the most important of all the factors controlling the vitality

of the insect, namely, its food supply. We can then represent the condition of affairs diagrammatically, thus :—



the arrows indicating the direction in which the reactions can proceed. Four arrows are shown on the diagram, indicating the four reactions, and one of the arrows, indicating the reaction of the insect on the plant, has been made much thicker than the other three. This is the reaction which it is our ultimate endeavour to control. How is this to be done ?

The most obvious method of controlling this reaction is the direct destruction of the insect. Were this as simple as it is obvious, the problem would have been solved long ago ! There is another method, however, not nearly as obvious, but vastly more promising. It is a matter of common experience, in the case of Mosquito Blight, that neighbouring areas are affected to a different degree by the pest, and that in many cases such areas may be of very small extent and quite close together, so much so that a few bushes in a section may be flushing strongly, while the rest of the section is almost shut up ; or a few bushes may be shut up while the rest of the section is practically unaffected. This will occur even when no control measures of any kind are attempted. In such instances environmental conditions would appear to be exactly similar in the two places, the reaction of the environment on the insect would be the same in both cases, the reactions of the environment on the plants would likewise be similar, and, as a consequence, the reaction of the plants on the insects would also be similar. These combinations of similar reactions result, on the one hand, in comparative immunity from attack and, on the other hand, in a considerable amount of damage, which is absurd, for it is a natural law that a combination of exactly similar circumstances will always produce the same results. If we refer again to our diagram we see that the environment acts on the insect in two ways, first, directly ; secondly, indirectly,

through the plant. Now the insect is a separate entity, complete in itself, capable of movement from one place to another. It is hardly conceivable that the direct influence of the environment on the insect would show material differences at two places so close together. The plant, however, is not a separate entity. Its existence is indissolubly bound up with the soil in which it is situated. Its reactions to environmental conditions are the sum total of the direct action of those conditions on the plant and the indirect action of those conditions brought about by its intimate connection with the surrounding soil. The soil is far from being homogeneous, and we know, of course, from the results of many observations, that different soils, and closely adjacent patches of similar soil, may differ considerably in chemical composition, mechanical constitution, and physical condition at any particular time. Obviously, the reactions of a similar combination of environmental conditions on two plants may differ according as their indirect action on the plant through the soil is modified by the nature and condition of the soil itself. This brings us to our second method of approaching the problem of control, which consists in the study of the conditions under which the plants succumb to, and resist, the attacks of the pest in nature, and of the methods by which the combination of conditions under which resistance to attack is found to obtain can be brought about in practice.

The problem of Mosquito Blight has, then, been approached from two different standpoints—first, the study of methods of destroying the insect directly, second, the investigation of the conditions under which the tea bushes resist and succumb to attacks and of the means whereby these sets of conditions are caused to exist.

First, the direct destruction of the insect. This might conceivably be brought about by either natural or artificial means of control. Natural means consist in the discovery and introduction of parasites and predators which, by feeding on the insect, will affect a diminution in its numbers. Artificial means consist in attempts to destroy the insect by collection in the various

stages, by mechanical means such as light traps, attractive baits, etc., or by the use of insecticides in the form of sprays or gases.

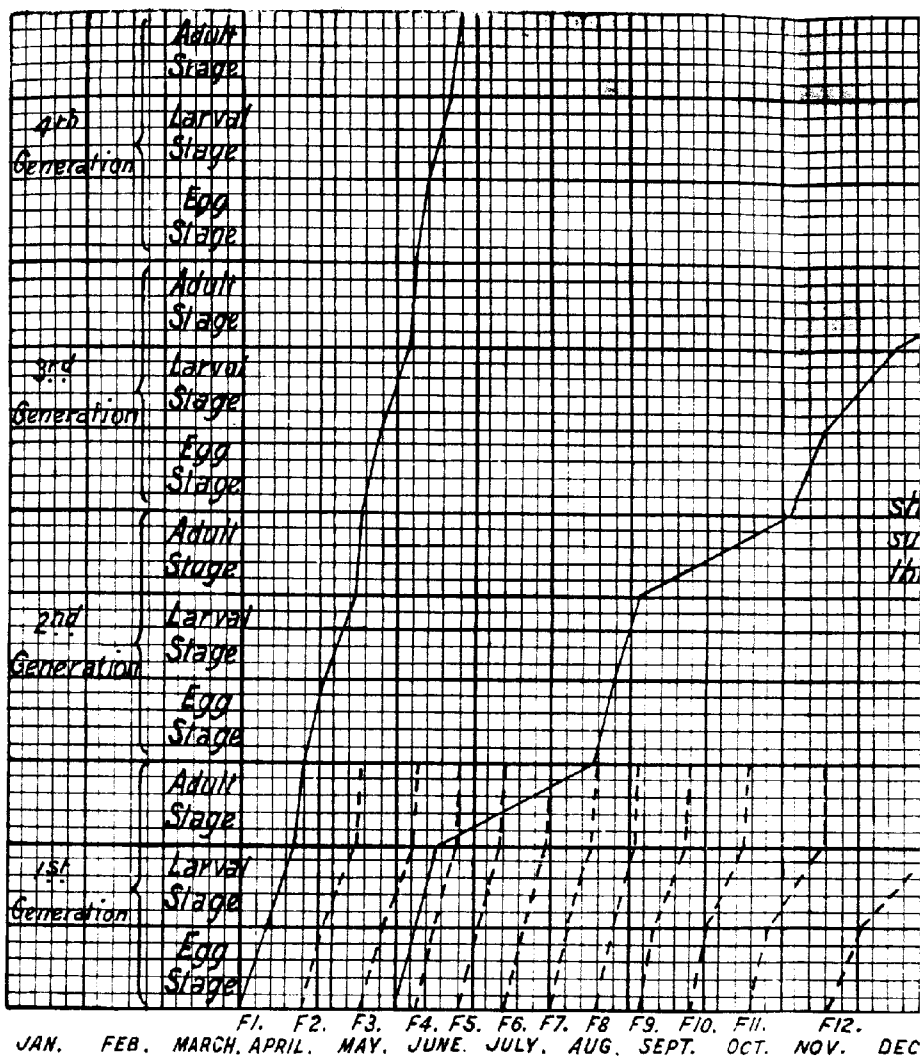
Several natural enemies of *Helopeltis* are known. Certain species of the praying mantis, certain predaceous grasshoppers, spiders, some predaceous bugs, will all feed on the tea mosquito, and at certain times even dragon-flies have been observed to follow the pluckers and catch the insects as they flew from the disturbed bushes. None of these feed solely on the mosquito, all are universally distributed throughout the tea districts, none flourish to a greater extent on gardens which offer an abundant supply of food in the shape of tea mosquitos than on gardens where the tea mosquito is not to be found. Two parasites have been observed. The more important of these is a *Mermithid* worm, the young stage of which is found in the bodies of tea mosquitos during the first half of the season. Parasitism by this worm allows the insect, in most cases, to reach maturity, but effectively destroys its powers of reproduction. This worm is already distributed throughout the tea districts and nowhere parasitises more than 2 per cent. of the insects caught, and has the further disadvantage that it, or some closely allied species, likewise parasitises a species of spider which feeds on tea mosquito. The other parasite is a small parasitic insect somewhat related to the ichneumons, and only one case of this has ever been noticed. It may be that in China and Japan, where damage by *Helopeltis* never seems to be reported, there is a parasite which effectually keeps the insects down and which might be successfully imported, but the indigenous parasites are not at all hopeful.

Before discussing artificial methods of control, it is advisable that we should consider the salient points in the life history and bionomics of the insect, as, without a knowledge of this, it is impossible to realise the difficulties in the way of control by artificial means. First, the tea mosquito, as it has unfortunately been named, is not a mosquito at all, but a true plant bug. It is important to remember this, as the non-recognition of this fact sets us wrong at the very outset. Methods of control

which are often advocated for the destruction of mosquito larvae are not applicable to the so-called mosquito blight of tea. The larva of the domestic mosquito is a wriggling worm-like grub, which lives in water; the larva of the tea mosquito is an insect, closely resembling the adult in all save the possession of wings, which spends its existence on the tea-plant, and never goes near water at all. The life cycle of *Helopeltis* is as follows:—The eggs are laid in the green stem, in the midrib of the leaves, and in the leaf-buds of the plant, and are entirely concealed within, and protected by, the plant tissues. During the cold weather the eggs appear to be laid mainly at the base of the unopened buds which are to be found on the branches, and near the base of the midrib of the older leaves. At the beginning of the season the green stems of the young shoots which come away inside the bush are the spots mostly favoured, though the eggs can also be found in the young shoots at the top of the bush. Later, a large proportion of eggs are found in the flush, and at the height of the season eggs are being laid in the young flush and in the broken ends of shoots from which the leaf has been plucked. The time of hatching varies from three to four weeks in the cold weather to six days in the height of the season. The young mosquito hatches from the egg as an active insect, provided with a perfect sucking proboscis, and capable of feeding on the young shoots. In this stage it is characterised by having long hairs scattered over its body, and there is no trace of either the spine which is to be found on the back in the older stages, or of the wings. After a day or two the insect moults, and the spine on the back appears, while the long hairs have disappeared. There is as yet no trace of the wings, which first appear at the next moult, and the young insect moults again three times after that, the wings and spine becoming more strongly developed at each moult, and after the fifth moult the insect emerges in the adult winged condition. During the whole of the time spent in the young stages, which may occupy a period varying from a month or more in the cold weather to a week or ten days at the height of the season in July, the insect feeds voraciously on the tea, but does not reproduce its kind. Reproduction takes place only

in the adult stages, and the female may live for two months or more, and may lay as many as 500 eggs, singly or in pairs, and scattered over a considerable area.

In the case of many insects, for example, the tea looper, there are a definite number of broods per year, and it is possible to state definitely that, say, the second brood of the insect will be in a certain stage at a certain time of year. In the case of the tea mosquito this is not so, for one might expect to find it, and one does find it, in all stages at any time of year. This state of affairs is caused by the fact that the period during which the female will live and lay eggs is longer than the period of time necessary for the eggs to hatch and the insects from them to become adult, and I have endeavoured in the accompanying diagram to show how this comes about. I have supposed that an adult female tea mosquito commences to lay eggs on the first of April. She will then continue to lay eggs for two months, that is, to the end of May. The first-laid eggs, deposited in April, will hatch out in nine or ten days, while those deposited in May will hatch out in six to seven days. Young insects, from eggs laid by this female, will therefore be emerging between the 9th of April and the 6th of June. The first insects to hatch, which emerge in April, will take twelve days to attain maturity, while those which hatched latest, in June, will become mature in about nine days. Insects from the eggs laid by this female will then be attaining maturity between, say, the 21st of April and the 15th of June. Now, these can begin to lay eggs two days after attaining maturity, and may continue to do so for two months, so that the first eggs laid will be deposited on about the 23rd of April, while the females which last emerge may continue to lay eggs until the middle of August. Thus the eggs which will give birth to the second generation (or brood) are being deposited between the 23rd of April and the 16th of August, and, by following a process of reasoning similar to that followed in connection with the first generation, we find that young forms will be present between the 2nd of May and the 3rd of September, and that adults will emerge between the 14th of May and the



Diagrammatic representation of the life-history of th
(*Helopeltis theivora* Waterh)

3rd of September, and that the eggs which are to give rise to the third generation will be deposited between the 16th of May and about the 5th of November. Following through in a similar manner with the next two generations, we find that, by the time the fourth generation has been attained, egg-laying, by individuals of that generation alone, will be going on the whole year through. In the meantime, it will be noticed that certain individuals of the second generation are in existence contemporaneously with individuals of the first generation, and that individuals of the third and fourth generations also will appear before the first generation has died out. And so it goes on throughout the season—beginnings of successive generations continue to appear at intervals of a month or less, less than three weeks, indeed, during the height of the season; and we find that by August we may have individuals of seven generations present in different stages at the same time. Also, we see that while four generations will carry the insect through the year it may, in the same period, reproduce itself to the fourteenth generation.

I have gone into this in some detail, as it has an important bearing on the question of artificial control. From what I have said, it will be seen that we have to deal, at one and the same time, with egg, young, and adult stages of several generations, some of which are the result of rapid reproduction, some of which are the result of slow reproduction, with corresponding differences in vitality. There are no specific periods during the season at which all the insects are in the egg, larval, or adult stages and at which the application of ovicides, larvicides, or insecticides can be recommended with confidence. If the adults could be attracted to light, or to attractive bait, over an extended period, good might be expected to accrue, but all experiments in this direction have given negative results. No ovicide is known which will kill the eggs without damaging the young shoots, but it is possible in the cold weather, after stick pruning, to destroy most of the eggs (perfect application would destroy all) which are present in the buds on the bushes by the application of an alkali wash. Here we are faced by the difficulty that, if

this be done on high pruned tea, it receives a slight check and comes away later, as all the buds are of course killed; and, unless the treatment be carried out thoroughly over the whole garden, and on any adjacent gardens, insects from other places will get into the tea soon enough to cause appreciable damage to the bushes.

Spraying with insecticides to kill the insects is of value where the attack is confined to a small area, if the treatment is commenced early in the season, and if the work be carried out efficiently and repeatedly. The majority of insects killed by such spraying are the young forms. These, when the bush is disturbed, run down the branches and take shelter at the base of the leaf stalks. If the bush be thoroughly soaked, the insecticide runs down the branches and collects in drops at those places, so that the young insects are immersed in a globule of liquid, from which they cannot readily escape, and are killed. For this sort of work, lime-sulphur is an efficient spray, and we find in practice that numbers of the adults are also killed by it. Many, however, escape the spray, and the work must be done several times. Spraying of this nature, carried out repeatedly during the season on a plot of $3\frac{1}{2}$ acres, kept the pest in hand, but by no means eradicated it. There are always the eggs, which are not affected by such treatment, and a few insects always escape to carry on. Early in the season, it is possible to notice when the young forms are emerging in greater numbers by examining the catches brought in by the children, and to apply the spray fluid at those times. Very soon, however, this guide fails, and recourse must be had to applications repeated at least once a week. One very disheartening feature of spraying is that whereas, in a year when the pest is not so bad as usual, comparative success may be attained, the same treatment, carried out in a year when the pest is more serious, may seem to be almost without result. Spraying on a large scale, where hundreds of acres are affected, is at present impracticable. As will readily be understood from the account of the life history of the insect which has been given, any spray fluid which is to

be completely successful in one application must kill the eggs, the young and the adults. The substance must, from the nature of the insect, be a contact insecticide, which will kill the insect only when applied to it. Since the insects are active, the insecticide must be sufficiently powerful to act quickly, yet it must be innocuous to the young foliage. The bushes must be thoroughly soaked, yet the ground must be covered rapidly. This necessitates a considerable outlay on machines, a considerable number of people, and thorough supervision, and at a time when all the available labour is required for the routine operations of the garden. It is conceivable that these difficulties might be overcome, but, in the absence of a perfect spray fluid, one is not justified in advocating the expenditure of labour, time and money which would be necessary for treating large areas. Certain spray fluids, notably those containing safrol and pyrethum as their principal ingredients, are excellent insecticides, but their cost is out of all proportion to their value, more especially since they will not kill the eggs, and more than one application, with an interval of not more than a week between each, is necessary.

Fumigation seems to offer more scope than spraying. This was tried with fumes of sulphur, but the erratic behaviour of the wind at that time of year militated against the success of the experiment, and the deleterious effect of the vapours on the foliage was a distinct drawback. It is reported that this treatment has lately been carried out with some success on a few gardens where mosquito blight is not particularly severe by taking advantage of the evening breezes. We propose to try some of the lately-discovered poisonous gases at an early opportunity.

We now turn to the possibility of controlling mosquito blight indirectly by treatment of the plants. This is a method of approaching the problem which does not appear to have received serious consideration before, but it is, I think, an enquiry which promises to afford a more reliable and practicable means of control than attempts to compass the direct destruction of the

insects. Much of what I shall have to say in this connection has been anticipated by the appearance of the fourth part of the *Quarterly Journal of the Department* for 1919, in which a short account of the work has been given. It will be remembered that, in the early portion of this paper, reference was made to the fact that the bushes can show resistance to the attack of the pest and that a consideration of the factors involved seemed to suggest that the nature of the soil surroundings might have something to do with the liability or otherwise of the bushes to attack. This line of enquiry has been followed up during the last few years. The first step taken was a general survey of the gardens in the different districts, an enquiry into their liability or otherwise to attack, and an examination into the characteristics of the soils, with a view to ascertaining whether any particular feature in the soils could be correlated with the distribution of the pest. Such was found to be the case, and it was discovered that, where the ratio of available potash to available phosphoric acid is low, there is a greater liability to attack than where this ratio is high. Details of these differences are given in my paper, from which I will now quote :—

“The soils in the Duars can be separated into four main types, though there are of course intermediate varieties :—

- (1) The Dam Dim type, a light sandy loam falling into the division 1, 2.* Gardens on this type of soil are exceedingly liable to suffer from attack.
- (2) The Dina Toorsa type, a heavier loam falling into the division 4, 2. Gardens on this soil also get blight.
- (3) The Red Bank type, a clay soil falling into the division 4, 1, on which many gardens have remained free from attack for years, although surrounded by blighted gardens, and on which, in some places, *Helopeltis* is beginning to obtain a foothold.

* See “Suggestions for Manurial Treatment of Tea Soils” by Hope and Carpenter,

- (4) The Hantapara Plateau type, a heavy loam falling typically into the 4, 2 division, and on which mosquito blight is now very serious.

The following table shows the relationships between the types, the figures given being the average figures obtained from the examination of a large number of soil analyses :—

Soil Type.	Total Potash.	Total Phosphoric Acid.	Available Potash.	Available Phosphoric Acid.	Percentage availability of Potash.	Percentage availability of Phosphoric Acid.	Ratio Available Potash. Available Phosphoric Acid.
Dam Dim Type ...	0.377 %	0.127 %	0.012 %	0.044 %	2 %	36 %	0.340
Dina Toorsa Type...	+0.854 %	0.170 %	0.018 %	0.053 %	†3 %	31 %	0.487
Red Bank Type ...	0.697 %	0.100 %	0.015 %	0.014 %	2 %	14 %	1.114
Hantapara Plateau Type ...	0.444 %	0.246 %	0.011 %	0.063 %	2 %	26 %	0.195

° Percentage availability means the percentage of the total amount which is present in an available form.

† These figures are for one soil only. There are no figures for total potash available for the others.

From these figures it will be seen that the relationships between the available potash/available phosphoric acid ratios referred to above are found to exist, even after the examination of a large number of soil analyses. Further, it may be seen that in the Red Bank Soils there is a much smaller proportion of the total phosphoric acid present in a readily available form, and that the percentage availability of the potash is about the same in all four types. In certain parts of the Red Bank, however, gardens are beginning to suffer seriously from mosquito-blight, notably in the Nagrakata district. A comparison of the figures obtained

in this district with those for the remaining typical Red Bank Soils is interesting :—

Soil Type.	Total Potash.	Total Phosphoric Acid.	Available Potash.	Available Phosphoric Acid.	Percentage availability of Potash.	Percentage availability of Phosphoric Acid.	Ratio— Available Potash. Available Phosphoric Acid.
Red Bank Type ...	0.697%	0.100%	0.015%	0.014%	2%	14%	1.114
Nagrakata Type ...	0.560%	0.147%	0.019%	0.028%	3%	18%	0.785

Another comparison can be made between analyses of Red Bank Soil made by Dr. Mann at a time when there was no mosquito-blight on the garden, and the analysis of a sample of soil taken from an area on the same garden which now suffers from mosquito-blight.

Soil Type	Total Potash.	Total Phosphoric Acid.	Available Potash.	Available Phosphoric Acid.	Percentage availability of Potash.	Percentage availability of Phosphoric Acid.	Ratio— Available Potash. Available Phosphoric Acid.
Dr. Mann's analyses {	0.82%	0.09%	0.029%	0.009%	3%	10%	3.222
	0.84%	0.06%	0.019%	0.019%	2%	15%	2.111
Recent analysis ...	0.774%	0.081%	0.007%	0.008%	1%	10%	0.875

There has been a loss in mineral constituents, and the balance between the two has been entirely upset, bringing about an approximation to grey loam conditions as regards the potash/phosphoric acid ratio, as in the case of the Nagrakata soils.

Turning now to Cachar soils, it is possible to divide them into teela, flat, and bheel soils. There is not as yet, however,

sufficient material to hand to enable one to work out the mechanical types, and the mechanical analyses available in any case show considerable variation within the limits of one class. It has, however, been possible to group together a large number of analyses from gardens which, though on widely different types of soils, fall into three classes, *viz* :—(1) those which remain free from blight, (2) those which get it badly at times, and remain comparatively free at other times, and (3) those which are always attacked.

Type.	Total Potash.	Total Phosphoric Acid.	Available Potash.	Available Phosphoric Acid.	Percentage availability of Potash.	Percentage availability of Phosphoric Acid.	Ratio Available Potash. Available Phosphoric Acid.
(1) ...	0.440%	0.168%	0.020%	0.010%	4%	6%	2.000
(2) ...	0.188%	0.56%	0.003%	0.003%	1%	5%	1.000
(3) ...	*0.499%	0.115%	0.010%	0.029%	93%	25%	0.345

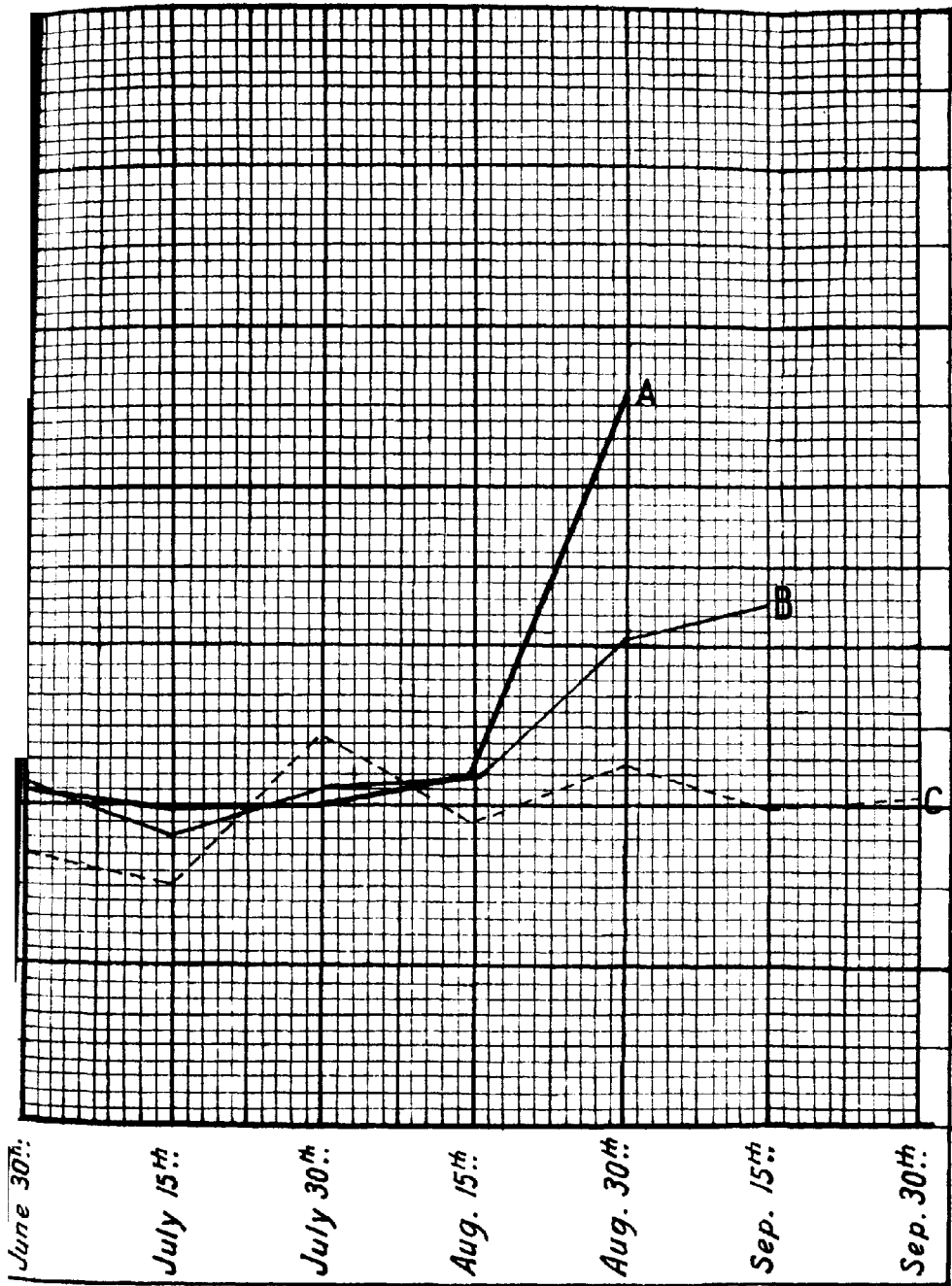
* Only one figure available.

Here, again, we see the same differences—an extremely low value for the available potash/available phosphoric acid ratio in the soils of blighted gardens, and a high percentage availability of phosphoric acid. Group (2) again occupy an intermediate position, and although at first sight the percentage availability of phosphoric acid appears to be low, this is due to the poverty of the soils, and when compared with the percentage availability of the potash the ratio can be seen to be 5 to 1, as compared with $1\frac{1}{2}$ to 1 in (1) and 8 to 1 in (3). Thus, in the two districts where mosquito-blight is always severe, differences in the severity of attack can be correlated with differences in the chemical composition of the soil, as above described.

The question then arises as to how differences in the chemical composition of the soil can affect the insect. No living thing can flourish in the absence of an abundant and suitable food

supply. The bush has to depend on the soil for nourishment, the insect relies on the bush. The character of the nourishment afforded to the insect by the bush will depend on the nature of the soil. An attempt was made to ascertain whether the feeding habits of the insect were at all connected with the potash/phosphoric acid ratio. Leaf was plucked from three gardens throughout the season. On one garden the tea was shut up by the end of August, on another the pest was serious, but the tea never quite shut up, while the third remained practically free from the pest. The diagram shows the curves obtained for the ratio of potash to phosphoric acid in the leaf from the three gardens. The thick curve, A, is that for the garden first mentioned, the thin curve, B, that for the second garden, and the dotted curve that for the third garden. It can be seen that in the case of the garden which remained unblighted the ratio of potash to phosphoric acid remained fairly constant throughout the season. In the other two gardens, as the percentage of punctured leaves plucked from the tea became greater, the ratio of potash to phosphoric acid increased, showing the greatest rise in the garden which shut up completely. Thus the relationship between the insect and the bush is in some way connected with the potash and phosphoric acid in the leaf, while the distribution of the pest can be correlated with differences in the relation of these substances to each other in the soil.

The question now arises as to whether these relationships are due to a more or less accidental preference of the insect for a certain type of bush, or to the fact that the pest cannot flourish to any extent on bushes of a certain character. From general observations the latter supposition seemed the more probable, as otherwise the factor of "jat" of bush might be expected to have more effect, but experiments were tried, by keeping specimens of *Helopeltis* under observation and feeding them on leaves taken from bushes which showed liability to attack in the one case, resistance to attack in the other. It was found that the insect flourished in the former case, and did much damage to the shoots, while in the latter case they did little or no damage to the



shoots, became listless, and soon died. Not only so, but it was found that insects which had become listless and had ceased to feed on the leaf from resistant bushes, could be brought round again by giving them leaf from bushes which had been seriously affected in the field, and that they would feed ravenously, and soon regain their former vigour. This showed that the insects did not flourish on bushes which resist attack, and points to the fact that bushes can attain a condition in which mosquito-blight cannot flourish on them.

The next thing was to endeavour to ascertain whether bushes in the field could be brought into a condition in which they would resist attack. The first step taken was the obvious one of adding potash manures to the soil and recording the differences in intensity of attack produced. The first experiment gave hopeful results, and a small dressing of sulphate of potash applied somewhat late in the season produced a distinct diminution in the intensity of attack. Further experiments were carried out on a more extensive scale on soils of different types, and results were not obtained in all cases. Where results were obtained, it was found that small dressings at frequent intervals gave the best results on light soils, while comparatively heavy dressings only gave a temporary effect on heavy soils, and small dressings had no effect. It struck the writer, from his observations and certain results published by other investigators, that when potash manures are added to the soil a certain proportion might be fixed and rendered non-available, this proportion being perhaps controlled by the percentage availability of the potash in the soil itself. The next step was therefore an experiment carried out on a garden where potash manures had shown little or no result, and consisted in giving an enormous dressing of potash to the soil, so as to allow of a distinct increase being made in the available potash in the soil, even though this fixation took place. This did not cause the mosquito-blight to lift, but whereas the surrounding tea, and neighbouring areas manured with light dressings of potash, became worse as the season went on, the area treated with the heavy dose of potash became no worse.

Thus the manuring experiments, while they afforded distinct evidence that potash did, in some cases, do good, were irregular, and far from satisfactory in that it became obvious that the factors causing the bush to be unable to benefit from the potash present in the soil also prevented it, to some extent, from benefitting from the potash manures added, and it still remained to be proved that if the bush could only get the necessary potash it would throw off the blight.

To do this it was evident that the soil must be eliminated from the experiments and direct injection of the bushes tried. In this connection the writer was fortunate in meeting Dr. Gough, of the Ministry of Entomology in Cairo, who gave him valuable information and advice culled from his experience in this line of work. As a result, experiments were carried out during the past season in which bushes which were absolutely shut up by the blight were directly injected with potash. These bushes, after a short interval, have thrown off the pest, and given splendid flushes, while untreated bushes in the vicinity remained shut up. The writer has spent a considerable time in watching these bushes, and it is interesting to note that the field observations thus made confirm the observations, referred to above, made with mosquitos in confinement. Tea mosquito after tea mosquito alighted on the treated bushes, prodded its proboscis into a few leaves without doing any appreciable damage, and then flew to a neighbouring untreated and already attacked bush, and remained there to feed. This is the most convincing point of all, for it is possible that the addition of potash might have forced leaf through by its stimulating effect alone, and it was not until one observed that the insects attempted to feed on the treated bushes, and gave it up, that one was justified in assuming that the desired result had been achieved."

A hearty vote of thanks was given to Mr. Andrews for his address, which was greatly appreciated by the Committee, and for the trouble he had gone to in preparing it.

COLLOIDS IN THE SOIL.

When a body is reduced to dimensions sufficiently small, gravity ceases to be the chief external force directing its movements. For small organisms, the viscosity of the medium in which they move is the chief force with which they have to contend just as, for the water spider, the surface tension of water is all important. When a small insect falls from a height it is buoyed up by the air owing to the relatively large surface area of its body compared with its weight, and therefore falls lightly. When an ant gets into a drop of water it experiences great difficulty in getting out because to get away from the liquid it must break through the surrounding "skin" which is formed by the surface tension. So it is with particles of matter. When they become too small to be seen under the microscope, forces, which with large particles were of secondary importance, become the only forces exerting any noticeable influence and we arrive at substances having new and distinctive properties.

Mica is ordinarily insoluble in water. If, however, it is finely ground and boiled with water, it dissolves. But the solution is quite different from that of a salt in water. In the latter case we must imagine the salt molecules somehow fitted into the spaces between the water molecules. With a solution of the mica type, we are not dealing with single molecules but with bunches or aggregates of molecules which are kept in suspension because the viscosity of the water keeps them from sinking. After a time several of these aggregates coalesce and the fresh aggregate becomes too heavy to be supported, and is precipitated. Exactly the same process goes on in the clouds. As the particles of water vapour coalesce a stage is reached when the air can no longer support the drop, and it falls as rain.

When mica dissolves in water we have a colloidal solution and any method which will form particles small enough to remain suspended and keep them from coalescing will give rise to colloidal solutions.

An essential fraction of practically all soils is clay, intermingled with which are fine particles of organic matter or humus. The other soil fractions—coarse sand, fine sand, silt and fine silt—form the framework of the soil and their function is chiefly mechanical. It is through the clay fraction that the soil reacts to the plant, for clay, owing to its fine state of division, is soluble in a manner similar to finely ground mica. It is on this account that the study of colloids is interesting to the agriculturalist.

There is a tendency for colloids to settle, owing to the coalescence of the particles. This process may be
Floculation of Colloids. hastened by the addition of acids or salts to the colloidal solution. The formation of deltas is due primarily not to the diminution of current when a river reaches the sea, but to the coagulation and precipitation of the suspended matter by the salt in sea water. Clay particles in suspension, like most colloids, carry an electro-negative charge and on this account the particles repel each other and are kept apart. If this charge is neutralised by the addition of acids or salts to the colloidal solution the particles then have no force to keep them from coalescing. The phenomenon of coalescence is known as "floculation."

The clay has two functions in the soil. First it is the medium through which most of the chemical action takes place and, secondly, it has the mechanical function, which it shares with fine silt, of binding the coarser particles together. In a soil under ordinary conditions we have the coarse sand, fine sand and silt fairly evenly mixed and, in the spaces between these particles, the fine silt and clay. In order that water may circulate freely in the soil there must be some free space between the soil particles. The action of puddling the bottom of a tank consists in breaking down clay and fine silt aggregates so that all the free space in the soil is filled and an impermeable mass is formed. A similar action takes place when land is cultivated in wet weather. Loss of tilth is the result. It can now be understood why a soil containing over 50 per cent. clay cannot be worked.

The tilth of a soil may be improved by the addition of lime. Lime itself is alkaline, but by the action of the carbonic acid in the air it forms a salt which is able to flocculate the clay in the soil. The result is that instead of the spaces between the larger particles being filled by minute clay particles, the latter are aggregated and the binding action is greatly restricted. Fine silt is not a colloid and hence carries no electric charge and is not coagulated by lime. In fact it is only after years of treatment with a combination of lime and green crop that silty soils become tractable. In this case the fine silt particles are probably simply cemented together, giving large aggregates of fine silt.

With a light soil, the free space is considerable and water movement is thereby facilitated. By capillary action, water is able to rise rapidly from a depth and in the dry weather there is a constant drain on the subsoil moisture as the surface soil dries. But there is a limit beyond which water cannot rise and when this limit is reached the plant suffers.

In the case of an extremely sandy soil we require just the opposite treatment from that necessary with a heavy soil and instead of aiming at the flocculation of clay we must attempt to disintegrate the clay aggregates. In this way more of the free space in the soil is filled and the water movement so restricted that the soil does not dry out rapidly. Such extremely sandy soils are, however, very rarely found cultivated.

When manures are necessary, the exact form in which they shall be added is, to a great extent, determined by the clay content of the soil. Suppose potash is needed by a heavy soil. This will be best added in the form of sulphate or chloride for both these salts show an acid reaction on addition to the soil. The flocculation of the clay which results brings about the desired lightening of the soil. On the other hand, a manure like wood ash or Hyacinth ash which contains its potash in the form of carbonate is not suitable for a clayey soil. Potassium carbonate is alkaline and leads to the deflocculation of the clay aggregates. If a nitrogenous manure is to be added, better results on heavy soils will be obtained by ammonium sulphate than by sodium

nitrate. The former, like potassium sulphate, reacts acid while the latter is alkaline. Quite apart from this point, however, the addition of sodium nitrate in a wet country like Assam is not to be advised on account of the tendency it has to leach out of the soil, as will be shown later. The best method of adding nitrogenous manure is by means of a green crop. The decomposition which must necessarily take place before the green manure is available as plant food, is much more rapid in light than in heavy soils. The explanation of this is that in a light soil the free space is greater and the quantity of air thus drawn into the soil is greater than in the case of a clay. The final decomposition of the green crop, which consists in the formation of nitrates, is brought about by bacteria which need air.

When clay is dried it naturally ceases to be a colloid, for its distinctive properties depend on the presence of water. Unless clay has been well dried or strongly heated, it regains its plastic and colloidal properties on the addition of water. This fact is of great importance in agriculture.

Usually there is a tendency for the soil to stiffen as we go downwards and this effect is pronounced in districts of heavy rainfall. With each rainy season a certain portion of the clay is carried down to a depth varying from less than a foot to several feet according to the heaviness of the rainfall. After two or three seasons an impervious layer is formed which, although it is not always apparent to the eye, is sufficient to cause plant roots to spread above it instead of going downwards. In some countries where the wet and dry seasons are very distinctly marked, the layer of the clay becomes dessicated to such an extent that when the rains come it is incapable of reassuming its old properties and resembles a layer of rock. This layer is known as a pan. The effect of a pan prevents the air and water movement within the soil to such an extent that its removal is imperative.

In California where Plowsoles (as pans just below the cultivation level are there called) are common, it has been found that the addition of gypsum (calcium sulphate) and sulphur minimise their formation. Gypsum is a salt and as such coagulates the

colloid in the soil. Sulphur is converted to sulphuric acid by a certain bacterium in the soil and acts in the same manner as gypsum.

It has also been observed in California that if the pan is broken in one part and free water movement made possible the whole obstruction disappears. Trenching in Assam has shown similar results. This is due to the continual wetting and drying which ensues as soon as free water movement in the soil is restored. If a piece of puddled clay is dried and then wetted and dried again often enough it eventually crumbles. It is also well known that the tilth of heavy soils is improved by drainage and the result here is again probably due to a repeated wetting and drying which brings about alternate expansion and contraction followed by crumbling.

A striking property of colloids is their power of removing dissolved substances from solution and retaining them often with great tenacity. This phenomenon is known as "Adsorption" and occurs with substances other than colloids. Thus charcoal can remove organic colouring matter from solutions and is employed commercially for clearing sugar solutions. Soil containing clay has the power of removing dyes from solutions. This property, which is quite common, is due to the relatively large surface exposed by the absorbent. Charcoal, for instance, retains the cellular structure of the wood and resembles a sponge. The amount of exposed surface of clay is enormous owing to the smallness of the particles.

When a manure like potassium sulphate is added to the soil, part of the potassium is immediately adsorbed or fixed and in exchange lime, magnesia, iron, and aluminium are given. If an ammonium salt is added, ammonium is fixed and the exchange goes on as above. In some soils the addition of gypsum leads to the liberation of potassium in exchange for lime. This probably accounts for part of the beneficial effect of super-phosphate which contains about 60 per cent. gypsum. The salt which is fixed is usually loosely held and becomes gradually available. The importance of this state of affairs will be fully appreciated, for, if

it did not exist, most of the soluble manures would be leached out of the soil before the plant had time to assimilate them.

In a general way it may be said that substances most likely to be leached out of a soil are soda, lime and magnesia amongst the bases, and chlorides, sulphates and nitrates amongst the acids. The substances most tenaciously held are potash, ammonia and phosphoric acid. These statements are verified by the analysis of the drain water.

The percentage of organic matter or humus greatly affects the mechanical part played by the rock particles in the soil. In a soil containing 2 to 3 per cent. organic matter, a small percentage of clay—about 2 per cent.—is essential to fertility. As the percentage of organic matter increases the necessity for clay decreases and in some of the soils of Southern Europe we have fertility in the entire absence of clay. The part played by clay is now taken over by the organic matter which exists in all stages from material which has not been decomposed to the simple decomposition products which are soluble and can be assimilated by the plant. Clay has several functions in the soil which are due to its colloidal properties and ultimately due to its ultra-microscopic size. Organic matter at some period during the process of degradation is capable of assuming these properties.

Plants grow quite well in pure sand provided that liquid food is added, but in the soil, the mineral food which is insoluble must be rendered available by the carbonic acid present in the soil solution. As the food comes into solution it is adsorbed or stored by the colloids in the soil till it is required by the plant. The nitrogenous food which originates from the organic matter in the soil is made available to the plant by soil bacteria which live in the colloidal medium. Without such a medium, the soil becomes an inert mass incapable of supporting vegetation.

It was at one time hoped that a complete soil analysis would tell the agriculturalist exactly the treatment necessary for his soil. This might be the case if fertility depended on one or two factors, but a soil analysis only reveals one set of factors which must be interpreted in the light of local conditions, such as climate,

water-supply and drainage. The result is that most of our work is empirical.

It has been shown that some of the most important properties of the soil are due to the presence of colloids in the soil solution. The elusive nature of colloids in general, makes it impossible to study the soil solution as it actually exists. The effect manures have on the plant growth takes place through the colloidal complex which coats the solid, inert soil particles. Thus fertilisers should not be regarded merely as plant foods. They affect in a greater or less degree practically every soil factor which influences plant production. Until these separate factors are clearly defined and their inter-relations thoroughly understood most of our agricultural practice must be based on experience.

C. R. H.

MANURING EXPERIMENTS.

Many gardens are now carrying out experiments to determine the influence of manures on leaf yield on their own soil and under the climatic and other conditions applying on their own gardens.

These experiments are always valuable; but would be much more valuable, even to the particular garden concerned, if reported to this department. Unfortunately they seldom are so reported, and it is often only when some touring officer happens to visit the garden that he hears that such an experiment has been undertaken.

When results are reported to us, it happens with disappointing frequency that the results are negative. That is, during the first year at any rate, the manuring has often shown no definite increase in crop; and in some cases the check plot receiving no manure has given the greater crop.

An old-established tea bush, with its wide and deep root range and great power of adapting itself to conditions, does not react to manuring so readily as a low growing annual crop with its roots entirely in the surface soil. Whereas we can hope to make an effective change in the nature of the shallow layer of soil occupied by the roots in the latter case, it must take a long time before the subsoil, which contains such a great part of the root system of tea, can be greatly modified by manuring.

The quantity of manure applied to tea also is usually small. For example, 30 lbs. nitrogen is an average dressing for tea, whereas to sugar as much as 150 lbs. is commonly applied.

We do not therefore look always for large and immediate returns from manuring tea, but the effect is cumulative. Any increase in the thickness or number of the shoots, any improvement of the root system, or in the general vigour of the bush

leaves that bush permanently improved as a leaf producer, even if the soil has not been permanently improved.

Our first point then is that any manuring experiments on tea must be carried on over a number of years, and not abandoned because the first year's results are disappointing.

Manuring is only one, and a comparatively small, factor in leaf production. Of far greater importance are the factors of temperature and humidity of the atmosphere, sunshine, soil moisture, tith of the soil and pruning.

The first three we can control but slightly and they are in any case practically the same for check plot and trial plot.

The very greatest care is necessary to see that the three latter are as nearly as possible the same for all plots.

Soil moisture is of course mainly affected by rainfall, but excess water may be removed by drainage, and in periods of drought water may be to a large extent retained by keeping the surface of the soil broken and by removing jungle.

Before leaving this question of soil water, it may be mentioned that manuring will have much less effect when the soil moisture is excessive, than when water is present in optimum amount, or even when water is deficient.

Some results with various manurial mixtures on wheat growing in sand in pot culture are given by J. W. Shive (J. Agric. Research. January, 1920) :

Average dry weight of tops.			
Water content of soil ...	10% water.	15% water.	20% water.
Least effective mixture ...	·17 grams	·32 grams	·34 grams
Most effective mixture ...	·64 „	·84 „	·59 „

Fifteen per cent. water was considered to be the optimum for the particular sand used.

In the case of every water-content the mixtures giving least effect and most effect respectively were the same except that with the wet soil slightly more potash and phosphoric acid were required ; but in the dry soil the most effective, mixture gave

over three times the effect of the least effective, with the optimum water-content $2\frac{1}{2}$ times, and in the wet soil only $1\frac{1}{2}$ times.

Here the plants were grown in pots kept at a steady water-content and there was no washing out of manure.

In any soil the amount of space not occupied by soil particles is fixed, and that part of the space occupied by water cannot be occupied by air.

In overwet soil therefore the aeration is deficient and the plant is unable fully to benefit from manures applied.

To obtain benefit from manures, then, drainage must be efficient.

Planters need not (as some do) hesitate to drain for fear of losing the effect of manures.

In manuring experiments it is therefore essential that all plots should be on the same level and be efficiently drained to the same depth and distance apart, and also that all receive the same cultivation on the same day.

The tilth will be affected by the past history of the soil which must be the same for all plots, and if all future cultivation is the same no change will be introduced except that produced by the manures.

Pruning will of course be as nearly as possible the same, but greater care than usual will be necessary to see that about the same amount is cut out of all plots. This condition may be very nearly approached by pruning with the same coolies on the same day.

It is useless to expect much increased yield from manures on tea the stems of which are thoroughly knotted and hide-bound. Such tea is useless for experiment other than experiments on manuring cut-back tea.

Another factor within our control, which may (and often does) mask the effect of manuring, is jungle growth. Jungle becomes a competitor with the tea for the manure, and with its surface-feeding fibrous roots is an easy winner. One plant

growing in the neighbourhood of another has a distinct poisonous effect on it. What this effect is due to is still a matter of controversy, but on the whole it seems probable that it is due largely to the roots keeping the soil charged with carbonic acid.

Whatever the reason, jungle undoubtedly injures tea and it is conceivable that not only may the jungle prevent the tea from benefiting from manures, but the extra growth of jungle produced may in some cases actually cause harm to the tea.

An example of the effect of jungle on sugarcane is quoted in the *Agricultural News* (West Indies) :

Plot.		Yield—tons of sugar.
F. Weeds allowed to grow...	No fertilizer ...	13·19
G. No weeds ...	... No fertilizer ...	20·38
D. Weeds allowed to grow...	Fertilizer ...	21·31
E. No weeds ...	... Fertilizer ...	29·37

When weeds were allowed to grow it is stated that weeding was done approximately as in the surrounding field—apparently these plots received the normal cultivation, but it is noted that at times the weeds were very bad. Plots G and E were kept entirely free from weeds.

The jungle factor must certainly be eliminated from manuring experiments by efficient cultivation.

The most important disturbing effect in experiments on tea is however original inequality of soil. All our soils are extremely patchy and it is extremely difficult to pick two or more plots of the same soil, although since similar plucking takes more leaf from the better bushes, and therefore tends towards “leveling-up” the bushes, the tea on two plots of different soil may look very similar to the eye. Differences show up much better on a new clearance.

If manuring can make an improvement of 10 per cent. it has been entirely successful and will probably show a profit; yet even if two plots are just ready to pluck no one could estimate by looking at the two plots a difference of 10 per cent. in the ready leaf.

To meet the difficulty of uneven soil we must have each treatment repeated on three or more plots distributed evenly over the experimental area, and we should, if possible, record the yields of all the plots for one or two years before the experimental treatment is commenced.

At Borbhetta 18 plots were marked out in 1916 on a flat piece of land requiring very little levelling. These were planted with one-year old plants selected from a large nursery so that all were of the same height and diameter at the base. Previous to planting tea, cowpeas were grown on each plot, and the weights of crop obtained varied considerably, but were extremely poor, always less than $\frac{1}{2}$ ton per acre.

As the soil was known to require phosphates, all plots were manured with a mixture of bonemeal and superphosphate giving 40 lbs. phosphoric acid per acre, which it was hoped would level up the plots.

The tea then grew quite well. In early 1918, 10 mds. slaked lime per acre were given to each plot. At the end of 1918 the tea was cut down to 2", and plucked at 27" in 1919.

Now everything possible has been done to keep these plots even, but the yields in 1919 varied from 503 lbs. green leaf per acre down to 346 lbs. and in 1920 (unpruned) the yields up to the end of May from 819 lbs. to 492 lbs. These two, the worst and the best plots, were certainly extreme cases,—the remaining 16 plots in 1920 varying only between 658 lbs. and 539 lbs.—yet they show how little single-plot experiments can be depended on.

These plots have now been divided into six series of three plots each, and the average of the highest yielding series is only 10 per cent. greater than the average of the worst series.

One of the six series has now received no further treatment, while each of the other five receives a different manure, and we shall therefore be able confidently to assign a difference exceeding 10 per cent. to the influence of the manure. Further, having now records of the original fertility of each series, we

hope to be able to get a closer approximation to the value of the manure by calculating the increased fertility per cent. on each plot, and by comparing the curves produced by plotting the pluckings monthly on squared paper.

On large areas of established tea greater equality between plots will be obtained by marking out the experimental plots in long narrow parallel strips, than by marking out square plots.

Where experimental plots have already been established without previous plucking records, one can frequently trace the influence of the manures by comparing the percentage annual decrease or increase of the manured plot with the corresponding decrease or increase shown by the check plots, even where comparison of the total yields gives a negative result.

H. R. C.

RIDGE-HOEING.

In the Toorsa-Jainti district of the Dooars one sees on practically every garden a system of cultivation in common use, which is not seen anywhere else in tea, except on a few scattered gardens, and these are usually managed by men who have come from the Dooars.

The system was first used to any considerable extent in old tea on the gardens of the Imperial Company superintended by Mr. Hamilton, but it spread rapidly over the whole district. Mr. Earwaker of Kalchini informs me that a similar system has been in use in the Dooars for 25 years, but was previously only used for burying heavy jungle in new clearances.

Its rapid spread is an indication that the method has some merit, particularly as it costs rather more than ordinary hoeing. Some account of it may therefore interest planters in other districts.

Mr. Ogg, now Manager of Chuapara, gives an account of the results of the method, as originally tried at Rungamutti:—

“In 1913 Hamilton commenced this ridging on a bad
“piece of tea growing on a slope, which with ordi-
“nary cultivation suffered badly from surface wash,
“and I can say from experience we used to pluck
“this part only every other round and it yielded
“about 4 maunds per acre, but after the ridging had
“continued with manuring for two or three years it
“improved out of all knowledge and is now quite a
“good block of tea. Here, of course, the ridging
“followed, as far as possible, the contour of the land,
“and had bunds at short intervals of from 5 to 10
“bushes apart to stop water getting any run on any-
“where. I think it was from seeing the effect here
“that Hamilton adopted the idea for the flat; first,

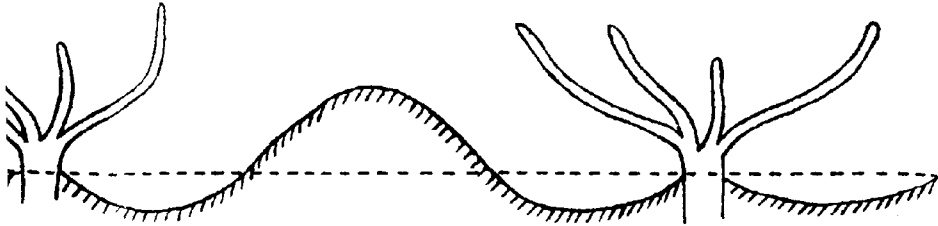


Diagram 1 - showing ridge between lines of bushes.

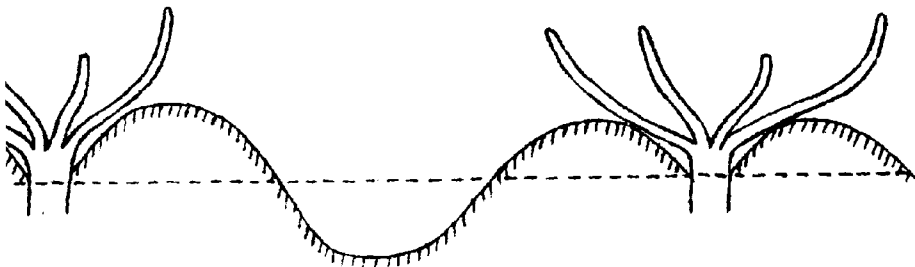


Diagram 2 - showing ridge along line of bushes.

“on stony ridges, where very poor cultivation is
“generally done.”

“I do not think the idea is new, as it has long been used
“in potato fields at home.”

The procedure followed is :—

1st.—To scrape up the jungle into a line between the bushes. In this work all the ferns and jungle and the soil around the collars of the bushes are scraped away, so that forking is rendered unnecessary.

Additional soil is scraped up over the “jabra” so as to make a ridge of soil heaped up about a foot high between the bushes (Diagram 1).

2nd.—At the next round of cultivation any jungle is again scraped off and the soil of the ridge dragged over it so as to form a fresh ridge, this time around the collars of the bushes (Diagram 2).

When the land grows jungle on the ridges banked up against the bushes, this jungle is commonly scraped off and buried in the gully between the ridges. Cattle manure also is sometimes so buried with the jungle. This procedure gets organic matter in deeply, and so provides some of the benefits of trenching with small expenditure of labour. Still deeper cultivation is sometimes obtained by trenching between the ridges.

Ridge-hoeing is on some gardens carried on right through the rains : on others the ridges are flattened out and the ordinary hoe used after about June. Some managers use the ridging instead of the ordinary cold weather deep hoe, while others do not.

In favour of the method it is urged :

- (1) that it destroys and keeps down jungle more efficiently than the ordinary light hoe. This is particularly noticeable when jungle growth is heavy.
- (2) that the work is extremely easily checked, and cannot be “scamped” without detection ; and that,

also, the coolies prefer this form of cultivation since they think they are hoeing only half the area.

(3) green crops are very easy both to grow and to hoe in.

The green crop is generally sown on top of the ridge when in the position shown in diagram 1. On the heaped-up top-soil of the ridge the crop grows better than on the flat. When ready for hoeing in the crop simply has to be scraped off into the gully and the ridge pulled over it.

Some planters favour the growing of the crop in the gully shown in diagram 2. Burial of the crop then becomes still simpler ; but generally a good crop cannot be grown in the sub-soil without more or less expensive manuring.

The above advantages, being mainly "conveniences" only, would not explain the great improvement in the tea, which, in the opinion of all those who use the method, follow the use of ridge-hoeing.

Cultivation can of course add nothing to a soil. Any permanent improvement resulting from cultivation must therefore be due to an improvement in the physical condition or tilth of a soil.

Tilth is produced in a soil mainly by its alternate wetting and drying, and it is clear that soil raised into ridges becomes subjected to this influence to a very much greater degree than soil left overlying wet subsoil.

Further the most important of the factors which enable a soil to retain its tilth is the admixture of organic matter. This admixture is very efficiently done by ridge-hoeing.

For the following reasons, then, ridge-hoeing should generally be a more efficient method of cultivation than the ordinary light hoe :—

- (1) it is more efficient in improving the tilth of the surface soil than ordinary hoeing ;
- (2) it treats a greater depth of soil than ordinary light hoeing ;

- (3) damage to the tea by jungle growing in its neighbourhood is more efficiently reduced by ridging than by ordinary cultivation.

Against ridge-hoeing it may be urged that however much the soil may be improved, it is of no great advantage to the garden if the tea does not get the benefit of the improvement; that a bush cannot benefit fully from its soil if the top-soil is either piled about it (or into it) or scraped up into a ridge between the bushes so that the lateral roots are actually or very nearly exposed for a great part of their length (a similar objection would of course apply to the very deep forking often applied in Assam).

It has also been suggested that the effect of exposing the lateral roots while extra soil is piled up around the collars, is to cause the old laterals to wither, while fresh ones grow from the collar. The writer has dug out a fair number of bushes from places where ridge-cultivation has been practised for years and neither this nor any other harmful effect on the roots was observed. There might be a tendency to such an effect where ridging is practised in the cold weather, but the method is not suited for cold weather cultivation.

Normally in a cold weather of little rain, the top-soil will dry quite readily enough if subjected to the ordinary deep hoe, and although ridging may be more efficient in that respect it will not provide that mulch of fine dry soil covering the whole surface, which is so essential as a means of conserving moisture in the soil during the dry weather.

It is, therefore, recommended that ridge-hoeing should not be commenced until rain has begun to fall—say March or April, and that the soil should once more be spread evenly over the roots by the end of June, and thenceforward ordinary light-hoeing be carried on till the deep hoe is commenced. The ordinary deep hoe is to be preferred to ridge-hoeing for cold weather cultivation.

On the flat, ridge-hoeing will be especially beneficial on heavy soils, and on stony soils where ordinary cultivation is particularly difficult.

On stones, ordinary hoeing is generally so inefficient that ridge-hoeing might well be carried on throughout the year.

It is on slopes, above all, that the benefits of ridge-hoeing are most clear. It is a method which provides perfect prevention of wash, but unlike terracing or bunding it allows the whole of the surface to be very efficiently cultivated. On slopes where no other method of wash-prevention is provided, ridge-hoeing should be carried on throughout the year.

H. R. C.

RESTRICTION OF CROP.

At a time when the price obtained for tea is such that the profit per pound is likely to be extremely small or possibly non-existent, it is natural that the question of restricting the output should be considered. While it is no part of the duty of a scientific department to offer any opinion on the necessity or otherwise for such restriction, yet if either the industry as a whole or an individual company should decide to follow this policy, a scientific department may perhaps be expected to indicate the lines upon which it appears likely that restricted output may best be turned to the improvement of the bushes which are to be subjected to less exhausting treatment.

It is the object of this note to discuss modifications of ordinary garden operations which may have the effect of carrying as much as possible of the unplucked leaf to reserve instead of leaving the whole of the reduction in crop as a dead loss.

Plucking :—Finer plucking at once appeals as a method of reducing crop. By taking younger leaf, a smaller crop may be expected, but that crop will be of a higher quality. If, however, labour is plentiful enough to allow of plucking sufficiently frequently, then a policy of finer plucking alone may not lead to any considerable decrease in crop, and the strain on the bush may be increased instead of decreased.

To carry out a policy of restriction of output combined with conservation of the bush, it is necessary that plucking shall not only be fine but sparing.

Most gardens have worked out a system of plucking which suits the particular garden, at least approximately. Where the soil is rich and forcing either naturally or by virtue of the manuring it receives, plucking is often closer and harder than on soils giving weaker growth.

Where a bush is being seriously overplucked, it sooner or later (and generally in the same season) ceases to yield as highly as it did with plucking suited to it. Over-close plucking for example produces before the end of the season an enormous number of very small shoots, which are very difficult and expensive to pluck, and weigh little, while in the worst cases die-back disease sets in.

So, within certain limits, experience leads a garden, or a whole district, to adopt a system suited to obtain maximum crop, while at the same time not subjecting the bush to any undue strain.

Whatever that system is, to carry out the principle of restriction of crop, it should be altered so that after each plucking more is left on the bushes than would have been left under the old system.

For example, wherever it has been the custom to pluck to the "janam," leaf should now be left to grow until two leaves and a bud can be taken while a third leaf remains on the bush. Even if the bush is so spared, it may still be necessary to pluck more frequently in order to avoid the necessity of having either to leave two leaves on the bush, or to pluck more than two leaves and a bud. For the sake of crop restriction it may seem quite satisfactory to leave two leaves instead of one; but as such strong growth will generally come from the centre of the bush, the effect will be to grow a conical shaped bush, thus tending to strengthen the centre to some extent at the expense of the outsides. It may, therefore, be necessary or at any rate desirable to pluck more frequently in order to obtain a smaller crop of higher quality without spoiling the shape of a bush.

The effect of such sparing will be seen in the better general health of the tea at the end of the season; and in the better pruning wood left.

Very weak bushes or even whole sections may be left unplucked for a whole season. In practically all cases, the effect will be complete recovery, which will be lasting. Bushes at

Tocklai apparently on the point of death from red rust, brown blight, or other disease having been so left are now good bushes and the trouble and loss of crop, which would have followed the infilling of a vacancy for years, have been saved.

China and hybrid bushes cannot be so left too long or they will produce flower and seed and so be exhausted more than they would have been by plucking.

Before leaving the subject of plucking it is necessary to consider the question of "breaking back," and this is mixed up with the whole theory of plucking. Unfortunately there are very few recorded experiments in plucking, and it is doubtful whether experiments so made would be of more than local value.

Theory tells us that a plant needs leaves to obtain from the air the most important part of its food (the carbon), and also to manufacture both this and all the other crude food material obtained through the roots into substances which can be assimilated. Therefore the greater the amount of healthy leaf, the better is the plant being fed.

One hears statements to the effect that the fewer leaves a bush has to support, the more shoots it can grow. That is not true. On the contrary, the leaf supports the bush.

It is however true that when a bush has developed too much leaf the bush will cease to flush, and will develop thick wood and extended roots, and eventually flowers and seed.

The greater the amount of leaf removed, the more is the vegetative growth of the bush stimulated. The bush has to develop sufficient leaf area to transpire all the water taken in by the roots.

An overplucked bush is having growth thus forced out of it, at the expense of its vitality. A correctly plucked mature bush will be so plucked that it is forced only so far as is safe. It will have no tendency to cease vegetative growth, and yet all its sap will not be forced into new shoots. There will be a sufficient balance for the proper maintenance of the bush.

In a time of crop restriction we may increase this balance so that the bush may grow better wood and better roots.

“Breaking back” takes leaf from our bush and we have no return for it, either in cash or in food for our bush.

It is therefore a dead loss and should be avoided as far as possible. It cannot always be avoided where a flat-topped bush is aimed at. Whether such a bush should be aimed at, is a matter on which there is great divergence of opinion.

Two facts are very greatly in its favour: it encourages the growth of strong side-branches, and it makes accurate plucking much easier for the cooly and more easily checked by the manager. It is possible however that it may sometimes be pushed to extremes, and a very perfect flat surface obtained at too great a cost.

Only exact experiment on the particular garden can decide.

The necessity for “breaking back” can be lessened by more frequent plucking, when labour is sufficient.

Manuring:—If leaf is to be left unplucked, there is no object in applying those manures which tend to increase production of leaf without permanently improving the bush.

Cases no doubt occur where a bush on a poor and exhausted soil is actually suffering from nitrogen starvation; but in modern practice such cases must be rare, and, in general, nitrogenous manures produce extra leaf without improving the general health of the bush. The quantities applied in tea cultivation are not generally sufficient to weaken a bush seriously, but there is a distinct danger of overmanuring with nitrogen (unless the manuring is very carefully balanced), and in certain cases the effects are visible in increased liability to blight attack—brown blight and mosquito blight in particular.

Such increased liability to blight may be seen where large quantities of oilcake have been applied annually without other manure, or where several hundred pounds per acre of nitrogen have been added in one application as cattle manure or bheel soil.

With artificial manures it is seldom that a maximum of 40 lbs. per acre of nitrogen is exceeded, and generally more care is taken to obtain a well balanced mixture. Bad results are therefore less commonly seen. This, of course, is generally simply because too much of the "natural" manure is applied at one time.

In normal times the limit of economical application is usually well within the danger limit, but there is still the tendency to increasing weakness with increasing crop from nitrogenous manures. A time of crop restriction therefore may well be a time for restriction in the use of nitrogenous manures also, particularly when manures stand at their present enormous prices.

There will, however, still be occasions when such manures are necessary, perhaps to save thoroughly deteriorated tea, or to encourage good growth after heavy pruning.

Potash manures also (probably partly because so rapidly absorbed by the soil) seem generally to be little required by tea soils, and their use may be discontinued except :—

- (1) for cut back tea, where potash has a special function in production of good wood, and
- (2) where potash has been found to have a good effect in decreasing liability to attack from disease.

In many cases potash has shown such an effect with mosquito blight and brown blight.

Phosphatic manures and lime improve the soil more or less permanently and add to the general health of the bush on very many soils. Where specially advised, their use should be continued although the quantities may possibly be reduced.

Generally speaking if full use is made of all the cattle manure available (at 5 tons per acre only) and as large an area as possible is sown with green crops, a garden will not seriously deteriorate for a year or two ; but, if plucking is less severe, will improve.

Pruning:—Any system of pruning to improve a bad bush as a leaf yielder must entail some form of heavy pruning. The common objection that such pruning leads to temporary reduction of crop is of less force if it is desired that crop shall be reduced.

The wider application of such pruning is a splendid method of reducing crop temporarily for the eventual benefit of the garden.

It is not recommended that any hard-and-fast rule should be enforced that any particular percentage of a garden should be heavily pruned: it would be absurd to cut down tea that did not need such treatment. On most gardens however there are sections which are too high, or contain too much bored and white-ant-eaten wood. Many sections also could be very greatly improved by the method of taking out centres. It is urged that a time when the profit per lb. of tea is small is the time when such work should be undertaken.

Heavy pruning as a means of renovating weak tea is a different proposition. The worst gardens one sees are generally those where the bushes, having become thoroughly weak, have been cut down to stimulate them to further efforts, while nothing has been done to remove the cause of the weakness which is usually to be found in the soil.

Really weak bushes should be strengthened before cutting down, and this is a case where economy in manure should not be observed unless it is preferred to strengthen up the bushes by leaving them unplucked, or at least plucking sparingly.

Cultivation cannot generally be reduced without damage to the tea of a more or less permanent nature, except that cultivation when the soil is very wet may be avoided the more readily when any temporary reduction of crop due to the presence of jungle will be of less consequence.

E. A. A.

H. R. C.

TOURING NOTES.

ENTOMOLOGIST.

The Entomologist visited the Hailakandy district of Cachar, the Longai valley in Sylhet, and the Bengal Dooars during June and July, for the purpose of commencing experiments on the inoculation of bushes growing in the different types of soil found in the worst affected areas. Thus bushes have been treated on a loamy flat in Cachar, on a bheel in Sylhet, on a grey loam soil, on a red bank soil, on a red bank soil of the Nagrakata type, on a soil of the Dina Toorsa type, and on a soil on the Hantapara plateau.

During the trip very little visiting of gardens was done, as the work on hand in connection with the experiments did not allow of this, and it was therefore not possible to make many observations. It was noticeable, however, that the effect of the previous year's drought was still being felt by the bushes, and this, combined, in some places, with the effects of hail, and in others with a severe attack of red spider, had resulted in the bushes having an appearance more generally associated in one's memory with an earlier part of the season. One gathered, also, from much of the heavy pruning one saw here and there, that the bushes had suffered a check which was hardly conducive to successful recovery from a second shock given by heavy pruning. An interesting case was observed which afforded an instance of how a soil may be altered when brought into cultivation, and not always for the better, although the yield may have been increased. The boundary between two adjacent gardens runs across the centre of a flat, which has been planted with tea, and the boundary is marked by a drain about two feet wide. On one side of this drain is tea which has received very little cultivation during past years, and which at the time of the observation was in jungle; at the other side is tea which has been cultivated regularly and in an increasing degree during past years and was fairly clean at the time. The soil, in the first instance,

felt, when handled, like a friable loam. It crumbled in the hand and ran through the fingers. In the other case, however, it squeezed up like modelling clay under pressure, and had the feeling of a sticky, heavy clay in the hand. Samples of these two soils were taken and analysed in the laboratory, and were found to have the same mechanical analysis, showing that they were originally identical. These differences accompanied a difference in the degree of liability to mosquito blight, for while the tea on the side of the boundary where the soil was intractable and sticky was badly blighted, that on the other side, where the soil was friable, was free, and this state of affairs is known to have been in existence for several years past. This is but one of the several instances we now know of, where a boundary-line between two adjoining areas of tea on the same lie of land marks the limit of serious attack by mosquito on the one hand, and of comparative freedom from attack on the other. Further information on the matter is needed, and is, moreover, being accumulated, but this particular instance is quoted as showing that not only can differences be produced in a given soil by our present methods of cultivation, sufficient to alter it from one on which bushes remain free from serious attack to one on which attack is always serious, but that such alteration does actually occur in practice.

A characteristic feature of many of the tea bushes on the bheels is the extraordinary rottenness of what first appears to the eye to be quite sound wood. Quite good bushes are to be seen growing on frames which, though they look well enough at first sight, are found on close examination to contain a large proportion of rotten branches. A consequence of this is that there is a sudden transition in many cases from thick, heavy wood to thin spindly shoots concealed beneath a crown of apparently healthy foliage. This, if there be anything in the theory that potash is of first importance in strengthening the wood, would seem to corroborate to some extent the idea that the bushes are not getting all they require in the way of potash in those places.

Many specimens of tea branches, having the appearance of being affected by canker, were received recently from the Longai valley. The Mycologist visited that district to enquire into the matter recently, and in his notes on the tour published in Part II of the Quarterly Journal, referred the damage to the Cachar Stalk-killing Mite, but there is considerable doubt as to this, and the matter is still under investigation. The treatment recommended by him, however, was to spray with lime-sulphur, and where this treatment was properly carried out it appears to have been entirely successful.

Mosquito-blight was, on the whole, less virulent in the Bengal Dooars than one expected to find it, and while it seems to have got a firmer hold on certain red bank gardens, is, if anything, less virulent in the west. It is curious to observe, more especially in the light of recent work, how different portions of a garden differ in their behaviour when attacked. Some bushes crumple up immediately, others grow in spite of the attack. More will be written on this subject after the next tour.

On one estate a very destructive form of attack by brown blight was observed in the nurseries, a whole nursery being reduced to leafless stumps in a few days. Examination of these plants showed that in some cases, though not in all, the cotyledons of the seed were rotten, and the rotten portion was crowded with rod-like bacteria. This form of attack has been commonly noticed, but only an odd bushes here and there before, and examination of the seeds attached to affected plants at Tocklai showed that in most cases the affected plants had sound cotyledons still attached to them, though in a few cases the cotyledons were rotten, and in others missing. The roots of the seedlings were good, but in some cases the collar appeared to be rotten. It appears as if the plants became liable to attack by brown blight at the period when they were ceasing to draw nutriment from the seed, and commencing to take it from the soil. In most cases the plant comes away again after a time, although all the leaves may have dropped off, and the plant has been reduced to a bare brown twig.

E. A. A.

COST AND PROFITS OF MANUFACTURE OF INDIGO IN ASSAM AS COMPARED WITH BIHAR

BY

W. A. DAVIS, B.Sc., A.C.G.I.,

Indigo Research Chemist to the Government of India.

I.—Present yields of Indigo in Bihar.

*Actual yields per acre (from Department of Statistics
Memoranda.)*

			Acres under Indigo.	Seers of cake Indigo per acre.
1916-17 ...	...	..	80,600	7½
1917-18 ...	...	...	86,700	6½
1918-19 ...	...	...	64,200*	5½
1919-20 ...	...	...	57,100*	8
			Average for 4 years.	7 seers per acre.

Possible yields—calculated from average analyses of plant.

Assuming yield of green plant per acre.	% leaf on plant.	% indigotin in leaf.	Theoretical yield 60% cake indigo if ex- traction were perfect.	Yield allow- ing a working loss of 30%	Actual aver- age yields 1918-20 per acre.
Mds.			Seers.	Seers.	Seers.
50	45	0.6	9.0	6.3	5½ to 8
80	45	0.6	14.4	10.8	Average 7 srs.

Total working costs per acre in Bihar (preparation of land, seed, sowing, carting and manufacture) average about Rs. 40 per acre. With a yield of 7 seers per acre, the cost of production of 1 maund of indigo cake = Rs. 228 ; with a yield of 5 seers per acre, the cost = Rs. 320 per maund.

* Fall in acres under indigo due to agrarian difficulties in Champaran. (Mr. Gandhi).

Actual selling price of Indigo (60% cake) per md. 60% indigo.

1918-1919 at Rs. 5-0 to Rs. 5-8 per unit = Rs. 300 to Rs. 330

1919-1920 „ „ 6-4 „ „ 6-8† „ = „ 375 „ „ 390

II.—*Prospects in Assam.*—Indigo grows most luxuriantly in Assam and the increased yield of plant as compared with Bihar is accompanied by superior quality (percentage of leaf and percentage of indigotin in leaf). The trouble in Bihar has been the *failing yield of plant*, owing to total neglect of proper manuring, and with this a deterioration in quality. In Bihar the yield of plant for the whole season is on the average 50 to 70 maunds per acre (2nd cuttings fail more or less completely), and the plant contains only 45% of leaf and 0.6 indigotin in the leaf. At Panchnoi the first cutting has averaged 150 maunds per acre, the second cutting will be at least 100 maunds and a third cutting is expected. In some cases in Assam a single cutting has given 300 to 400 maunds of plant per acre. Assuming yields of only 200 and 300 maunds per acre (probably low estimates) for the whole season we have—

Probable yields of indigo per acre in Assam.

Yield of plant per acre.	% leaf on plant.	% indigotin in leaf.	Theoretical yield of 60% cake indigo per acre.	Deduct 30% loss in working.	Probable yield of cake indigo per acre.
Mds.			Seers.	Seers.	Seers.
200	50	1.0	80.0	24.0	56.0
300	60	1.0	120.0	36.0	84.0

The leaf percentage and percentage of indigotin are based on actual determinations made with Assam-grown plant.

These anticipations of probable yield of cake indigo per acre have been confirmed by recent results at Panchnoi factory, after the preliminary difficulties in finding the proper time of steeping had been overcome. Mr. West has obtained yields of 24 to 36 seers of indigo (analysing 50 to 60%) per 100 maunds of plant,

† Rise of selling price due to increased demand from Japan and the formation of a pool to control sales.

which if the yield of plant for the whole season be taken as 250 maunds per acre works out at 60 to 90 seers of cake indigo per acre.

The quality of the Panchnoi indigo is still somewhat low (50 to 60%) but there is no doubt that by correctly ascertaining the optimum time for steeping (which should present no great difficulty) higher grade indigo (60 to 70%) can be obtained in exceedingly good yield.

Profits.—If we assume for Assam an average cost of working of Rs. 100-130 per acre (as against Rs. 40 in Bihar) we have the following probable profits for different yields of indigo per acre and different market prices of the indigo in the future.

(a) *With average produce of 24 seers cake indigo per 100 maunds plant (average working).*

Yield of plant per acre.	Cost of working per acre.	Yield of cake indigo per acre.	PROFIT PER ACRE WITH INDIGO SELLING AT		
			Rs. 200 p. md.	Rs. 300 p. md.	Rs. 400 p. md.
Mds.	Rs.	Seers.	Rs.	Rs.	Rs.
200	100	48	140	260	380
300	130	72	230	410	590

(b) *With average produce of 30 seers cake indigo per 100 maunds (good working).*

Mds.	Rs.	Seers.	Rs.	Rs.	Rs.
200	100	60	200	350	500
300	130	90	320	545	770

III.—*Market price of Indigo in the future.*—From this table it is seen that with yields such as have actually been obtained at Panchnoi and are to be expected from the quantity and quality of plant grown in Assam, the profits per acre are altogether extraordinary. With indigo selling at Rs. 400 a maund (as at present is the case with Bihar indigo) with average working yielding 24 seers of indigo per 100 maunds of plant, a growth of 200 maunds per acre of plant would give a profit of Rs. 380 per acre, and 300 maunds of plant a profit of Rs. 590.

With better working (with favourable bacterial conditions in steeping,) giving 30 seers of indigo per 100 maunds of plant, the profits would be Rs. 500 and Rs. 770 per acre and according as 200 or 300 maunds of plant were obtained per acre.

There is at present no falling off in the market price of indigo—in fact during the past year, owing to demand from Japan and better organisation of sales, the price of indigo has increased from Rs. 300 to Rs. 400 a maund. But in the future competition with synthetic indigotin from Germany, England and America will have to be faced and this competition can be easily met by Assam indigo owing to the extraordinary yields obtained per acre. It is extremely doubtful whether “synthetic” can be produced for many years to come at a price below Rs. 200 per maund. The pre-war selling price was Rs. 120 per maund on the basis of 60% indigotin. With the big rise in price of coal in Europe (from say 15s. per ton to 50s. per ton or more at pit's mouth) which has occurred since 1914, the cost of all raw materials for synthetic indigo has enormously increased. Some of them have increased four or five fold in price, whilst the price of labour, plant and buildings have also increased greatly. There is too an actual shortage of some of the raw materials (such as formaldehyde) which limits output. So that in my opinion Rs. 200 is probably the minimum selling price for synthetic indigo for some years to come. There is an enormous demand for indigo in China and Japan and this is at the present practically untouched by the limited output of synthetic.

Even if the selling price of Assam indigo had to be lowered to Rs. 200 the profits from Assam-grown indigo are still very handsome ones.

Plant yield per acre.	Produce at 24 srs. per 100 mds. Produce at 30 srs. per 100 mds.	
	(average working) profit per acre.	(average working) profit per acre.
Mds.	Rs.	Rs.
200	140	200
300	230	320

From these figures it is clear that natural Indigo *grown in Assam* should have no difficulty in competing with and excluding entirely from the Far-Eastern markets (which take roughly one-half of the world's supply of Indigo) the artificial competitor synthetic Indigo—which in the past largely displaced natural Indian Indigo, owing to the miserably poor yields obtained in Bihar from exhausted lands. Once synthetic Indigo were choked Indian Indigo would have a monopoly and within reasonable limits could fix its own price.

IV.—*Manurial value of Indigo seet for Tea and other crops (such as Sugarcane).*—In the above table of profits no allowance has been made for the very great value of the Indigo seet (refuse from the steeping vats) as a manure for other crops. The high value of the seet as a *manure* has in fact largely kept the natural indigo industry alive in Bihar during the 10 or 15 years preceding the war. Indigo seet has exceptional value as a quick-acting nitrogenous manure for forcing *leaf-growth*. Land which ordinarily only fetches Rs. 20 per acre in Bihar can after manuring with Indigo seet (300-400 maunds per acre) be let out to ryots to grow tobacco at Rs. 120 per acre. The development of tobacco in Bihar has depended almost entirely on the use of seet as a manure. Now in Bihar the growth of Indigo is so poor that the seet obtained from 4 or 5 acres of Indigo has to be used for manuring 1 acre of land. But in Assam, with a luxuriant growth of Indigo (300 maunds or more per acre) the seet from one acre would be sufficient to give a heavy dressing of manure for one acre.

There is no doubt that the use of Indigo seet as a manure for tea would go far to reduce and largely obviate the necessity for use of other nitrogenous fertilisers (cake or artificials); this in view of the greatly increased prices of such fertilisers would add considerably to the real profit per acre derived from the Indigo.

It must be remembered too that the mere growth of the Indigo (or leguminous crops) as shown by Bihar experience, brings considerable nitrogen into the soil irrespective of the

value of the seed, and that it can be grown on poor sandy soils which ordinarily fail to give other crops owing to lack of nitrogen.

V.—*Value of Indigo on newly opened Tea Estates.*—Indigo could be grown with great advantage on newly opened or newly cleared tea-land. On newly opened estates it would enable large profits to be made in the period of waiting (4 or 5 years) in which tea comes into yielding. On new extensions it could be grown between the young tea bushes for two or three years and during this period would enrich the soil with nitrogen.

VI.—*Market for Indigo.*—(For statistical data see my article in *Agriculture Journal of India*, January 1918.) In China and Japan there is an immense market for natural Indigo only waiting to be supplied with the right material in paste form similar to the 20% synthetic paste of the Germans; of recent years China and Japan have consumed considerably more than half of the European production of Synthetic Indigo. In 1913 China and Japan took 27,081 tons of 20% Paste out of the total German and Swiss *export* of 47,282 tons. 27,081 tons of 20% Synthetic supplied to China and Japan represents 9,027 tons of 60% cake or 270,810 Indigo maunds of 74·66 lbs. ($=\frac{2}{3}$ cwt.) this quantity would have a present value of Rs. 1,083 lakhs if sold at Rs. 400 a maund (current price) or Rs. 542 lakhs selling at Rs. 200 a maund.

The total pre-war *production* of Synthetic Indigo was estimated at 55,000 tons of 20% paste, that is 18,333 tons or 550,000 maunds of cake Indigo (60%) with a value of Rs. 2,200 lakhs selling at Rs. 400 a maund, or Rs. 1,100 lakhs selling at Rs. 200 a maund.

The recent output per annum of Bihar has been about 3,000 chests or 12,000 maunds which is less than 1/20th of the requirements of China alone or 1/40th of the world's requirements of Indigo.

INDIGO ON TEA ESTATES.

Mr. W. A. Davis, the Indigo Research Chemist to the Government of India, gave an address to a conference held at Shillong on the 17th September 1920, pointing out that very large profits are to be expected from Indigo-growing in Assam.

The facts on which this opinion is based are likely to be of such great interest to those planters who see little prospect of profit from tea in the near future, that the notes by Mr. Davis giving the substance of his address are here published in full.

Mr. Davis in his paper points out the great advantages of growing indigo on newly opened estates.

Indigo can also be grown among established tea.

Tea planters have long appreciated the advantages of growing leguminous crops such as *arhar*, *boga medelou*, and *coupeas* among the tea for manure, and know how to obtain good crops.

Indigo also is a leguminous plant ; and though it may not give such a large weight of green stuff per acre as the green crops now generally used, yet the advantage of making a large direct profit out of one's green crop is great enough to outweigh this disadvantage. Even this disadvantage is counter-balanced by the superior quality of the manure obtained.

Mr. Hutchinson, the Imperial Bacteriologist, has recommended that green manures should undergo a preliminary steeping in water before being applied to the land and has shown very clearly the advantages of this procedure (see I. T. A. Quarterly Journal, 1916, Pt. III, page 47 ; Pt. IV, page 130).

His method of so treating green manures has not been generally adopted by the tea industry because the extra cost is not likely to be repaid, in climates where the rainfall is so favourable to the ordinary method.

Steeping is a necessary part of the manufacture of indigo from the green plant, and the efficiency of the manure ("seet")

remaining after the dye has been extracted, is very much greater than that of the raw green stuff.

By growing indigo among our tea we shall not cause our soils to deteriorate, but when the seed is returned to the land, actually improve them.

The crop of tea obtained while the indigo is actually growing will probably be found to be somewhat diminished, the loss being small when rainfall is ample, and comparatively great during a dry period.

On soils especially well suited to the crop, at least 100 maunds of indigo plant per acre (in 3 cuttings) will probably be obtained from indigo sown in alternate rows.

The best soils will probably be found to be sandy soils, rich in available phosphoric acid, not too acid, and with sufficient humus.

On the other hand it is probable that the crop is not worth trying on a sticky clay, which is deficient in phosphoric acid, very acid, and in bad condition generally.

Intermediate soils will in many cases require manuring, but on a large number of tea soils no more than 2 maunds per acre of bone-meal (about Rs. 10) will be necessary. Some lime also will often be found advantageous. In both cases such manuring will permanently improve the tea. Planters may judge of the likelihood of success with indigo, from the degree of success obtained in growing other green crops: for example, if 4 tons per acre of cowpeas can be grown in 6 weeks then failure with indigo need be little feared.

Since the additional cost of growing indigo among the tea (which must in any case be kept in cultivation) is likely to be small, profit is to be expected even from poor crops.

The capital expenditure necessary for tanks, machinery, etc., for dealing with 150 acres of indigo (average crop 200 maunds per acre) is estimated at about Rs. 30,000 for kutchha buildings, or about Rs. 40,000 with pucca roof, floors, etc.

H. R. C.

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SOIL DRAINAGE.

This article is not written as a complete dissertation on the difficult and complicated problem of soil drainage but rather as a short note in which are mentioned some of the more important points in order to stimulate a greater interest in this, one of the most important of agricultural operations. Too little attention is often given to this problem, doubtless because it means a very large expenditure of money. On the other hand it must be realised that until a soil is properly and efficiently drained it is impossible for it to be in the best condition for yielding maximum crop returns, and in fact it is often the controlling factor that retains the crop at its present low level. Before however it is possible to arrange a drainage scheme for a garden it is necessary to fully appreciate exactly what is required and expected. What is meant by drainage? Certainly not the mere cutting of drains at certain intervals in an area. The drainage of an area of soil implies the removal from the soil of excess water that is not required and the means employed to bring this about is the drainage system. Some few soils, owing to climatic conditions, their geographical situation and their physical conditions, etc., eliminate excess water naturally and without any artificial aid, but this is not so in the vast majority of cases. Natural drainage as a general rule is insufficient to meet the requirements in this direction of the tea plant, which is or should be deep rooting if it is to resist the varying extremes of climatic conditions that pertain to North East India.

Since drainage then is the removal of excess water from the soil, it is necessary to enquire what is excess water. Any naturally situated piece of soil consists of soil particles made up of small pieces of rock and mineral matter and organic matter, etc., patched together in a more or less loose manner, leaving in between the particles interstices which can be filled with fluid substances such as air or water. If such interstices are com-

pletely filled with water the soil is water-saturated. For agricultural purposes it is necessary that these interstices be filled partly with air and partly with water, the water being in the form of a film spread over the solid particles. Such water is held together as a film by capillary force and cannot be removed by drainage. The amount of water so held in a soil varies with the type and class of the soil. As the amount of water increases so the force retaining it entirely as a film becomes less until a point is reached where what may be termed free water is present, that is to say water that can be removed by drainage, and the object of drainage is to remove such water, for its presence in the soil means that it is occupying space between the soil particles that should be filled with air, and aeration of the soil is in consequence deficient. It will be noted that film water cannot be removed by drains and film water is able to supply the full need of a growing plant provided the root formation of the plant has suitably developed, which can only be when the soil is sufficiently aerated. A soil that at one time is unduly filled with water and at another time has no excess water will not permit of proper root growth, and plants in such soils often suffer severely from drought. There is with all soils a certain definite water content that renders the soil in its best physical condition. This point is readily recognised by expert gardeners from the feel and appearance of the soil and it is then in the best condition possible for producing maximum plant growth. The water content of the soil at this point is known as the optimum water content and it is as close to this point as possible that it is desirable to keep the water content of a soil. A soil in which the water content is below this point is unduly dry and above this point the soil contains too much water. The optimum water content of soils varies considerably according to their nature, but is lower with sandy soils than with clay. In the case of a peat bheel it is very much higher than with clays. As instances the following may be cited of tea soils.

A sandy soil has an optimum water content of about 15%.

A clay soil has an optimum water content of about 20%.

It has already been explained that excess of water in a soil means a deficiency of aeration in the soil, but this is not the only ill effect arising from insufficient drainage. Excess water aids in the formation of pans in a soil, formed largely of iron and aluminium silicates, and this is easily noticed on many insufficiently drained tea soils. Excessive quantity of water in a soil increases soil acidity partly in a direct manner but also indirectly by bringing about lack of aeration and the prevention of oxidation and by modifying the development of the various forms of micro-organisms in the soil. It also causes certain plant food substances which in a well aerated soil would be in the soil solution to be removed from solution either by precipitation or adsorption. Nitrogen, potassium and phosphorus can all thus be rendered non-available for the use of the plant. The non-availability of the plant food in a soil is a very general feature of many of the badly drained areas of tea. It may be noted that manures added to such soils usually exert but little influence on the tea. They are rendered non-available. The general effect then of non-drainage of a soil is to render the plants growing there unhealthy and much more liable to disease attack. To mention but one or two of the pests and blights that are more commonly in evidence on such plants ;

Red spider, Red rust, Root diseases, Mosquito blight, and on Sau trees, canker.

It is of course obvious to every one that a low lying piece of land, surrounded by higher land, where water stands after rain, is in need of drainage but it is not always so obvious to casual observation that level land or land gently sloping is in need of drainage, and still less obvious if the land is at a steep slope, and the remark is often heard "such and such a piece of land can't want drainage, it is naturally drained." This is in the majority of cases not correct and a further study at all times of the year of the water conditions in the soil will soon reveal the fact. Another class of soil that is often supposed by reason of its situation to be drained is a high plateau. In some cases the top soil on the plateau is of a good open texture but under-

neath at no great depth is a subsoil of a clayey nature and this may be saucer-shaped, deeper towards the centre of the plateau, and nearer the surface at the edges. The water is then held in and the whole drainage is towards the centre where the water accumulates. On plateau land the permanent water level is often very far below the surface even in the rains, but on account of the close texture of the subsoil the water that accumulates in the top soil cannot percolate sufficiently rapidly through the subsoil and in districts where rainfall is very heavy in a few months of the year as in the Duars, where 200 inches may be precipitated in about 3 months, the water accumulates in the surface soil to such an extent that the soil becomes almost saturated. Such soils can only deal successfully with a very evenly distributed rainfall without any heavy precipitation. Badly drained soils owing to the bushes being shallow rooted suffer more from drought than well drained soils and this is particularly noticeable in the case of heavy clay soils. Another feature of badly drained soils is that the early flushes of the tea bushes are good, but that later on, commencing for example with the third flush and continuing until September, the flushes are not as good and as heavy as they should be. This is due to the advent of the monsoon and the heavy rainfall leading to waterlogged soil, drainage being insufficient to remove it rapidly enough.

Many times emphasis has been laid upon a form of cultivation that in clay soil districts having a heavy rainfall is often practised, and that is light hoeing when the soil is thoroughly wet. It has been the writer's misfortune to see hoeing being done on a clay soil whilst heavy rain was actually falling and had been doing so for some hours during the monsoon period and when the soil would certainly be nearly saturated. It has been repeatedly pointed out that this puddles the soil and effectually prevents proper drainage and aeration. The reason for doing this that is often given is to find employment for the coolies, but it is surely possible to find a form of cultivation, *i. e.*, forking or hand weeding that shall not be doing damage to the soil; drainage also can generally be improved, and this work is easy during the rains.

A form of cultivation that is with great advantage employed on tea gardens is trenching and this does a very great amount of good in ameliorating soil conditions, but there are certain points to be noted in this connection. On sloping land if trenches are made on the contour they act as catch water drains and on heavy soils or soils not sufficiently well drained may and do cause the retention of water in the soil during the wet weather. On the other hand trenches cut at right angles to the drains and to within 6 inches of the drain sides greatly assist the removal of water. An effective and satisfactory manner of improving drainage on soils where the permanent water level is well below the surface is by growing deep rooting trees. What particular kind of tree should be planted needs the careful attention of garden managers. For instance, on some gardens Sau trees do well and the root system develops deeply, but in other cases it develops almost entirely on the surface and the tea in consequence usually suffers, or gains but very little benefit. In another instance that came before the writer rain trees (*Pithecolobium saman*) were exerting a very beneficial influence on the tea by breaking up the subsoil and causing the tea to take deeper root, and by improving the soil drainage, yet this tree as a rule does not have any good effect upon tea. In areas in which drains are about to be made it is of essential importance in most places that correct levels be first obtained by means of surveying instruments. It is impossible on gently sloping or undulating land to determine by the eye the most suitable direction for the drains. It is also of importance that when drains are made they should be at a proper distance apart. Drains cut too far apart are often seen, with the result that the area is not efficiently drained. On heavy soil drains need to be cut at 20 feet distance, beyond this distance they are too far apart. On lighter soils the distance can be increased, but drains cut further than 40 feet apart cannot usually do the work required of them. The depth of drains is also another matter of great importance and 3 feet appears to be the minimum depth of practical advantage. When first draining a water-logged section in which the roots are shallow it is not always desirable to cut the drains to the full depth at once. They

should be made in the first year to a depth six inches below the root depth and each succeeding year deepened until a minimum of three feet is obtained. If made to the full depth at once the *bushes* are liable to suffer until the roots have grown downwards. Another point that needs to be remembered is that drains once made do not efficiently perform their duties for ever. The movement of the soil water towards the drains carries with it the finer clay particles of the soils, and these gradually accumulate at the drain sides until the interstices of the soil become largely filled in by such small particles and the rate of movement of water through the soil close to the drain side becomes very much restricted. This happens more rapidly in soils containing large quantities of clay and is not so noticeable in soils where the finer particles of soil are absent. In such cases it is necessary to cut new drains in the adjacent line of tea and when the sides of the new drains in their turn become clogged another drain can again be cut in the original line.

In the tea districts the form of drains used has been almost entirely confined to open drains, but another form of drainage which has met with marked success in many countries is that known as tile drainage. It has not found use in tea largely *because of* the initial expense, but it has certain definite advantages. One of great importance is the elimination of wash on slopes. The tiles being buried beneath the surface of the soil do not interfere with cultivation. This form of drainage, if tiles can be locally obtained, is worthy of careful consideration.

A little book that has recently been published entitled "Drainage for Plantations" by Claud Bald will be of interest to planters in this connection.

P. H. C.

LOCALLY OBTAINABLE MANURES.

Nowadays, when every Tea Planter is considering restriction of crop and reduction in expenditure, the question of manuring becomes extremely complicated. In most cases, the addition of manure is made with the object of obtaining a return the same season in the form of an increased crop. From this point of view, manuring at the present time will naturally not be undertaken. However, from another standpoint the question is quite different. On many gardens the soil has been "made" by years of hard work and careful consideration. A silt is not rendered tractable, nor a clay lightened, nor a sterile sand made fertile in one season. The work stretching over years is continuous, and soil which has been got into "good heart" should not be allowed to deteriorate because of the state of the tea market. A soil in good condition is the garden's greatest asset, which should not be allowed to suffer depreciation. Organic matter always, and frequently lime and phosphoric acid also, are necessary for the maintenance of condition. The most expensive item of a manuring programme, nitrogen, may generally be left out when immediate leaf production is not required; but some nitrogen should, if financially possible, be applied to cut-back tea.

In the present state of the tea market, manuring should be confined to the minimum necessary to maintain the soil and bushes in good condition and it is of course necessary that the cost of such manuring should be as low as possible. It is the object of this article to enumerate those locally available manures which are relatively cheap, and to indicate the most economical methods of application.

Cattle Manure.—With the idea of permanently improving the soil our thoughts naturally turn to cattle manure, which can frequently be obtained on the spot at a low cost. It is

interesting here to note some of the remarks made by Dr. E. J. Russel, F.R.S., at a meeting of the Farmers' Club on 31st May 1920.

"Not many years ago it used to be the custom for certain representatives of agricultural science to extol the virtues of artificial manures, while farmers, on the other hand, stoutly maintained the superiority of farmyard manure. In recent years the position has changed. It is now the scientific worker who emphasises the importance of farmyard manure and the need for making and storing it properly. Farmyard manure and artificial fertilisers do not compete with one another; they serve quite different purposes in the soil. No farmer can do without artificials, no matter how much farmyard manure he may have at his disposal, and conversely, no arable farmer, except in a few special districts, would like to do without farmyard manure, even if he could have unlimited supplies of artificials at very low prices. The best results are always obtained on arable land by proper combinations of farmyard and artificial manures although on grazing land farmyard manure may not act well.

So far as is at present known, the effects produced by farmyard manure in the soil are three :—

1. To supply nitrogen and potash to the plant.
2. To improve the physical condition of the soil, and thus increase its capacity for going into a good tilth and holding water. The effect of this is to steady the yield.
3. To assist some of the micro-organisms of the soil.

Only in the first of these is there any competition with artificial fertilisers, and even here the competition is restricted, because artificials usually exert their full action on the crop to which they are applied, while farmyard manure does not."

The loss of the urine from cattle manure as usually collected in Assam, renders it of very small value as a potash manure, but of much greater value as a phosphatic manure than it is in England.

The chief effect of cattle manure is seen in the tilth of the soil. On a heavy soil the manure may be added as soon as collected, but on light soil it should be well rotted, otherwise its effect may be to render the soil still more "open." Well rotted "humus" will on the contrary exert a beneficial "binding" action on such soils.

A question which follows is that concerning the most efficient storage of cattle manure. On this subject Agricultural Chemists have not yet come to a final decision, but it is clear that during the making, it should be kept from exposure to the weather and should be covered by a roof or a layer of earth. It should also be kept as tightly compacted as possible. It is estimated that in England, at present prices, the value of cattle manure is increased by about 3s. per ton, bringing the total value to 15s. per ton, by the provision of a shelter.

The composition of cattle manure varies so greatly according to the methods of collection and storage that it is difficult to fix any average, but as delivered on the garden it will have approximately a value of about 4 annas per maund, and as it can generally be obtained at very much less cost, its use will prove economical compared to imported manures. As pointed out in a previous number of this Journal, cattle manure is commonly applied to tea in doses too large. In economical use, it will be applied at not more than 5 tons per acre.

Such an application will not result in any rush of leaf, nor will it render bushes more liable to blight attack, but will secure the soil from deterioration.

A full account of cattle manure, its making and storage was given in *Quarterly Journal* Part III, 1918.

Oil Cake.—The next most common local manure is oil cake. Its use at present, however, is not advised, not only because of its high price, but also because its chief function is to increase the nitrogen supply and hence the leaf. Where nitrogen is essential however it may pay to use oil cake where obtainable at less than Rs. 3 per maund. The nitrogen content is usually

about $4\frac{1}{2}$ per cent. The latest prices of artificial nitrogenous manures work out to about Rs. 18 per unit of nitrogen. At this rate oil cake would be worth Rs. 81 per ton, about Rs. 3 per maund, or rather more on account of its content of organic matter and a small percentage of phosphoric acid.

Recent experience at Tocklai has shown that its action may be very slow. In the case referred to, the locally bought cake contained an abnormally high oil content of 15 per cent. Its rate of decomposition and consequent rapidity of action would be increased if used in conjunction with lime or wood ashes, and it is also helpful to use very small quantities of cattle manure with it.

Wood Ashes.—A local manure of great value, yet generally neglected, is wood ashes. If coolies could be induced to bring in ashes from the lines, a very efficient manure at low cost would be obtained. Clean wood ashes would probably average about 10 per cent. potash and 5 per cent. phosphoric acid besides some lime. Line ashes which are mixed with earth would contain possibly half these values. Tea soils are usually well supplied with potash, but with cut-back tea an extra supply is particularly useful. The potash is present as carbonate, which salt, together with some lime, reduces the soil acidity. The charcoal present in the ashes greatly improves the soil tilth and probably has some more complicated action. Thus, by virtue of the great surface, charcoal, which still retains the cellular structure of the original wood, is capable of absorbing and storing ammonia which would otherwise escape and be lost to the plant. There is also evidence to support the idea that charcoal removes soil toxins. Wood ashes followed by a green crop is an ideal treatment for improving the soil condition.

Assuming that line wood ashes contain 5 per cent. potash their present value (taking the value of potash as Rs. 8 per unit) on this constituent alone is about Rs. 1.6 per maund, and it would certainly be profitable to pay anything less than this sum to induce coolies to bring in wood ashes.

Coal Ashes.—Coal ashes cannot be used as a manure. Analyses carried out at Tocklai have shown that they contain sulphur in various combinations poisonous to the plant. Exposure to the air brings about the oxidation and destruction of these compounds, but even then the fused glass-like substances (clinker) which make up the bulk are useless as manure, and the most economical use of such material is to put it on the roads.

Soot.—Sometimes limited quantities of factory soot are available. Household soot may contain up to 7 per cent. ammonia. Factory soot may contain as little as $\frac{1}{2}$ per cent. nitrogen, but that is as much as is contained by average cattle manure. Soot contains its nitrogen in a very readily available form and also exerts a good mechanical effect on clay soils.

Bones.—Some tea companies are now paying Re. 1 per maund for bones which after crushing are used as a manure. Bone meal now costs about Rs. 5 per maund. Experiments at Borbhetta have shown that bones even when in pieces measuring from a half to two inches in length are still effective, though much slower in action than finely ground bone.

Jungle.—Green jungle contains all the potash, phosphates and lime which are found in wood ashes, together with nitrogenous and organic matter which the latter, of course, lack. The nitrogen averages about 0.04 per cent. of the total green stuff and this, with other constituents has been proved at Borbhetta to be in a form readily available, so that it could be used for cut-back tea. Similar, of course, is the action of green manures, though in this case the tea suffers during the time the green crop is growing.

Three tons per acre of cut green jungle (excluding wood more than finger thick) will be about the required dressing.

As a manure for cut-back tea it should be hoed in, in the spring, so as to be lightly covered with soil.

Unsaleable Tea.—It has been suggested that low grade tea, the sale of which does not pay for boxes and carriage, may be used as manure.

Tea, of course, contains the valuable constituent *caffèine* which could easily be extracted on the garden. As however the market for this substance is very limited, it would become valueless if a large supply were thrown onto the market, and the manufacture of *caffèine* in India on any scale would mean the loss of the American market for tea unfit for human consumption.

It is possible, therefore, that *caffèine* manufacture does not offer any very bright prospects. Waste tea, assuming it to contain about 2 per cent. nitrogen, $1\frac{1}{2}$ per cent. potash and $\frac{3}{4}$ per cent phosphoric acid would be worth about Rs. 50 per ton as manure, or about 4 pies per lb. only. Its use as manure therefore can only be justified when its sale would result in a profit of less than 4 pies per lb. Its value to the bush will be very much greater, if by finer plucking, the poor quality leaf is left on the bush, when it will function as an active provider of manufactured food.

AVERAGE DRESSINGS.

For maintaining soil in good condition :—

- (1) Cattle manure 5 tons per acre, applied at any time when labour is available.
- (2) Bone Meal ... $1\frac{1}{2}$ maunds ... } about April.
green crop ... }
- (3) Wood ashes ... 8 maunds ... } about April.
green crop ... }
- (4) or where phosphates are not greatly required, (*e.g.* many Dooars gardens.)
green crop only about April.
- (5) Green jungle or a specially grown green crop, trenched in. This is of very great value on heavy soils, or soils in which a pan has formed.

For cut-back tea—

- (1) Cattle manure 5 to 10 tons p. acre { any time, probab-
Wood ashes ... 5 mds. p. acre { ly best before
cutting down.
- (2) Soot ... 2 tons p. acre }
Wood ashes ... 10 mds. p. acre } about April.
- (3) Green jungle ... 3 tons p. acre about March.
- (4) (a) Oil cake ... 5 mds. p. acre {
Wood ashes ... 5 mds. p. acre }
- (b) Oil cake ... 4 mds. p. acre { mixed *immediate-*
Cattle manure $\frac{1}{2}$ ton p. acre { ly before appli-
Wood ashes ... 5 mds. p. acre { cation and ap-
plied about Mar.
- (5) Unsaleable tea ... 12 mds. p. acre about March.

C. R. H.

TEMPORARILY ABANDONED TEA.

The simplest method of reducing crop is to stop plucking certain areas. If such areas are kept in cultivation the gain in the vigour of the bushes will be very great, and this method of improving the weakest sections is recommended to those gardens which can afford it. In many cases, however, expenditure on areas yielding no immediate return will be financially impossible, and such expenditure is in any case a consideration.

It is well to consider, therefore, what will be the effect of temporarily abandoning tea altogether.

In the first place the effect on *the soil* of leaving it uncultivated, will do nothing but good. The root action of the resulting jungle, the addition of humus due to such vegetation as dies and decays, and the entire absence of the puddling effect of heavy rain and of cultivation when wet, will result in a great improvement in the "richness" and the tilth of the soil.

But the effect of the competition of the jungle for water and food, and the poisonous effect of so many plants crowded into its neighbourhood, will do so much damage to *the bush* that, if such conditions persist for long, recovery when the jungle is removed may be very slow.

Of even more importance is the probability of the establishment of undesirable weeds in the area. Among the weeds which will certainly establish themselves are various grasses with deep long underground stems, such as thatch (*Imperata arundinacean*), and Kohuan grass (*Saccharum spontaneum*). Quick growing trees, and shrubs such as "Futuka" or "*wild rhododendron*" (*Melastoma*) will also establish themselves in a single season.

Apart from the labour involved in digging out shrubs and small trees, it would in many cases require years of cultivation and green cropping to free, from undesirable weeds, land which

had been allowed to relapse into jungle. To prevent this state of affairs it will be desirable to establish, among the tea, plants which possess if possible all the following properties :—

- (1) Easy removal when required.
- (2) Rapid and vigorous habit of growth which will enable the plant to compete with and suppress jungle.
- (3) It should be a tall plant, because tea does not suffer from shade unless it be very dense, and actually benefits from light shade, while shade will keep down the worse types of jungle. Low-growing plants, such as cowpeas, etc., will not keep down the growth of tall grasses, which would grow through and above the low plant, and a low plant growing into the tea bush will do it more damage than a tall plant branching above it.
- (4) It should be a leguminous plant which will not only be largely self-supporting in respect of nitrogen, but will also actually enrich the soil in this respect.
- (5) It should, if possible, provide a crop of some monetary value, but in the case under consideration this is of minor importance, since if the crop produced is of considerable value, inter-cultivation and other attention can be afforded for the area.

The plant which most nearly fulfils all these conditions is Arhar (*Cajanus indicus*). Boga medeloa (*Tephrosia candida*) is generally not so rapid in growth, but might be substituted on poorer soils where Rahar does not grow vigorously.

Dhaincha (*Sesbania aculeata*) would do quite well for one year, but would not often be very satisfactory if it had to be left for a second season.

Neither of the latter provide a seed crop of any value, while a crop of value as food would always be obtained from Arhar, although in many districts insect attack may render the crop a small one.

Indigo, although not so quick-growing or hardy, also fulfils the necessary conditions very fairly ; but the crop whether of leaf for manufacture of dye, or of seed for sale or for future use, is of sufficiently high value to warrant more expense and attention than is contemplated in the case of the other plants.

Sowing should be in every line, at the rate of about 4 seers per acre. Land should be clean at time of sowing ; and sowing should anticipate the early rain, probably March would generally prove best.

At this seed rate the plants would be closer than necessary and it would be advantageous to thin out to about 6" apart when the plants reach the height of the bushes. The plants pulled out should be left on the surface of the soil, and this mulch will be of considerable assistance in keeping down weeds.

If it is decided that the planting of green crop among the tea is too expensive, some effort to keep down the jungle should still be made.

Probably it would prove cheapest, and at the same time fairly efficacious, if the jungle were sickled whenever it reaches the height of the tea. The cut jungle should be left lying on the ground between the bushes.

In bushes so left unplucked, particularly if heavily shaded, it is to be expected that "sides" will be altogether lost. When the area is again taken into cultivation, it is probable that the branches approaching the horizontal will have either died or become so weak that they are better cut away. Since sections showing healthy, flushing sides will probably not be chosen for abandonment, it is probable that this loss of sides will prove of little practical importance ; and the small number of nearly perpendicular, straight, healthy branches will provide a fine framework on which to build up a healthy wide bush.

H. R. C.

REDUCTION AND RETRENCHMENT FROM THE ENTOMOLOGICAL POINT OF VIEW.

One year ago the writer committed himself to the statement that this Scientific Department "exists for no other purpose than that of co-operating with those concerned in production with a view to maintaining the quantity and quality of the product at as high a level as possible."*

Nothing can emphasize the rashness of committing oneself to anything more than the fact that this same Department now finds itself considering ways and means of reducing output—a form of activity quite foreign to precedent, and one which necessitates the adoption of an entirely opposite policy. All must deplore the necessity for such a *volte face*, but this fact should not prevent us from giving the matter even more careful consideration than has been given to increase of production in the past. It is much easier to decrease than to increase production—but—we all know our Brahmaputra; and while we know that progress is more rapid down stream than up let us not forget that the difficulties of navigation between the shoals are greater.

One of the possible effects of decreased expenditure on a tea estate which must never be lost sight of is that which it will have on the insect enemies of the plant. The fact that where work has been best in the past our insect enemies are least troublesome requires no advertisement, and makes it obvious that if retrenchment be carried out carelessly damage is bound to accrue. On the other hand, at a time when a slight loss of crop is a matter of little moment, the planter is placed in a position whereby, with the exercise of a little care, he might be able to exert a considerable influence over his insect enemies, which will be of benefit later on.

* Indian Tea Association, Scientific Department Quarterly Journal, 1919, page 56.

There is a tendency, at a time like this, to contemplate the intervention of an insect pest with comparative equanimity—the man whose garden is not attacked may even regard it as providential—but it would be deplorable if, when the good times come later, it should be found that our insect enemies have gained such an ascendancy as to prevent our taking full advantage of the return to better conditions.

A difficulty besets one at the outset. Will the season 1921 be favourable or unfavourable for tea? Should it be favourable, well and good, but an unfavourable season, coming at a time when a policy calculated to reduce crop has been pursued, might render it impossible to make even the reduced estimate. There is admittedly a risk, but while it might, at a certain stage of the game, be advisable to exchange pawns, it may be laid down that as a general rule it is more profitable to exchange a bishop for a queen. Moreover, if it has been decided to pluck certain areas very sparingly, there is always the possibility of taking a little more from them later to make up a deficiency.

In adjusting one's policy of retrenchment and decreased production to meet the requirements of the entomological point of view as far as possible, one fundamental fact should be kept in mind. In its natural state tea can, and does, compete successfully with its insect enemies, and achieves the object of its existence, which is the production of seed. Even our arch enemy the tea mosquito has no terrors for the owner of a seed-bari. By stimulating the bush to produce leaf unnatural conditions have been brought about which reduce the plant's power of resistance, and the more leaf the bush is stimulated to produce, the greater the departure from natural conditions and the less its power of resistance to attack by pests and blights. The writer was recently shown a section of tea, on a garden in the Duars which suffers badly from mosquito blight, which, in a year of comparative freedom from blight, is said to have given 10 maunds of pucca tea per acre. The bushes were old, and for the most part poor, China bushes. There must have been 30 per cent. of vacancies and at least 30 per cent. of the bushes were nominal

vacancies.* Such tea, in a district like the Jorhat district, where mosquito blight, though present, is not a factor in production, would give, at the utmost, 5 maunds in the most favourable year. Cases of this description are of frequent occurrence, and there is more than one instance of a garden which, pursuing a more or less old-fashioned policy, maintains a steady average outturn and remains free from mosquito blight, while neighbouring gardens, more up-to-date, and producing very high outturns in some years, in other years suffer very seriously from attack by the pest.

Now it has been found in America in the case of fruit trees that trees which are allowed to remain in a state of nature for a year or two will become almost free from certain scale insects which attack them severely after they have been cultivated for a few years. Trees so left can be brought back into cultivation and made to give heavy crops for four or five years, when the scale insects will again gain the upper hand and the trees are left again. Such a policy, modified to suit the circumstances, might be pursued with some advantage in the case of estates which suffer badly from mosquito blight. Badly affected areas might be left unpruned, unplucked, and uncultivated, either wholly or in part. The area should, however, be by no means abandoned. It might probably be necessary to pluck the centres of the bushes lightly, to prevent them from growing up at the expense of the sides. It would certainly be advisable to sickle the jungle at intervals, to admit light and air to the bushes and prevent the sides from being smothered. Such a rest would do much to increase the powers of resistance of the bushes to attack by sucking insects.

A further suggestion one would like to see carried out in the case of a mosquito-blighted area is to burn the prunings, not on the road side, but between the lines of tea. One has heard of this being done with success in the past, but since it could not be explained why the insects should not afterwards get into the area from round about, and since the treatment appeared to

* *i.e.*, unproductive bushes.

be somewhat drastic, the idea made small appeal. We have recently found, however, that land on which fires have been lighted before being planted with tea gives extraordinarily vigorous plants. This seems to indicate that the partial sterilisation of the soil produced by the heat of the fire is beneficial, and this may very probably have been the cause of the successful results referred to above. Under present conditions, also, the objection to the burning of the bushes disappears, since a slight loss of crop is of no moment, and tea generally recovers remarkably well from fire.

Another practice which might be discontinued is the reprehensible one of taking off the young shoots and buds "before the mosquito gets them." The bushes may or may not come through if left, but they at least get a rest and a chance, of which they very often avail themselves, while if young shoots are being removed by the pluckers as well as being nipped by the insects the bushes get no rest and no chance.

The above suggestions will probably commend themselves little, if at all, to many. They are, of course, largely experimental, and perhaps, in the case of the first two at any rate, only the existence of an abnormal state of affairs like the present would justify their adoption. It does seem, however, that with a market such as the present one, on which only the best teas command a sale, it is false policy to continue to make as much tea as possible early in the season, before mosquito gets it, with the accompanying certainty of making no autumnal teas.

Before leaving this subject one danger of leaving part of the area unpruned, unplucked, and uncultivated must be pointed out. That danger is the advantage which will thereby be given to pests over which a considerable control is exercised in the ordinary way by the operations of pruning and cultivation. Pests such as borers, looper, faggot and bag-worms, in fact all caterpillar pests, and termites will be given every encouragement by such conditions. They will not kill the bushes by any means, but unless they are watched they might very well undo much that is the result of careful work in the past. In practice, therefore,

it will probably not always be possible to avoid cultivation altogether, or even a certain amount of pruning. Should looper make its appearance, for instance, it would be advisable to put in a hoe after the caterpillars had disappeared, as otherwise the pupae would be left undisturbed in the ground to attain maturity, and the adults would be enabled to infest other parts of the area. Borers, likewise, would have to be cut out, or they would increase in numbers and spread to other parts. Termites would not do much damage in the rains, but a thully in the cold weather, and again at the end of the rains, would probably be advisable. In such matters as this a garden manager would have to exercise his own discretion.

Mention of termites draws attention to a common practice in termite-infested areas. It is generally recognised that it is advisable to cut out termite-ridden branches, but branches which are not yet so badly damaged as not to give leaf are often left with the idea of getting a little more leaf from them before removing them. This means that the insects are left for another season in a position whence they can readily extend their depredations to the base of neighbouring sound branches, and by gradually interfering with the proper flow of sap into those branches, render them moribund and in a fit state for attack. At such a time as this it would seem advisable to remove such branches when pruning. There will then be a certain loss of crop during this period of crop reduction but in the meantime new branches will be forming against the coming period of full production.

The above suggestions for taking advantage of the needs of the moment and exercising means of insect control which would not be practised in normal times are not, of course, of general application, but are suited to a few particular cases. It is more than probable that on the majority of gardens the necessary reduction in crop will be readily effected by a system of finer plucking, with its accompanying advantage of the production of a higher proportion of better grade teas, and that reduction in expenditure, if brought into operation, will be

general over the estate, and result in cheaper pruning and cultivation, and less manuring. This being so, it behoves one to consider the probable results of such a policy in so far as the incidence of insect pests is concerned, and the possibility of ameliorating any harmful effects which may arise.

Finer plucking may be carried out in two ways. Finer leaf may be plucked as soon as ready, or the finer portions of more mature leaf may be plucked, leaving the remainder on the bush. The former method will take more out of the bush, the latter method will take less out of the bush. Since the former method results in forcing the bush to a greater extent than the latter, it may be expected, as is indeed known from experience, that pests like red spider, tea mosquito, and green fly will, should they occur, have a greater effect on the plant. From entomological, as well as general reasons, therefore, the latter method is to be advocated.

Cheaper pruning will, of course, tend to bad workmanship. Bad workmanship means snags, followed by bark-eating and other borers, termites, etc. Bad pruning is ordinarily least harmful in high-pruned tea. Any saving in expenditure should therefore be made on the high-pruned sections, and not on the low and medium-pruned sections. It is of the utmost importance, when heavy-pruning tea, to cut out bad wood as far as possible. Apart from the general truth that unsound branches can never be expected to give thoroughly healthy shoots, bad wood is always attacked by some insect or other, water collects in it, and fungi breed on it. Not only so, but the insects and fungi present on it are in a position to sap the vitality from neighbouring branches. It may be, that on some estates where a policy of renovation is being followed, it will be decided that at a time like this a larger area may be cut down than was originally intended. It should not be forgotten that medium and heavy pruning requires a good deal of supervision, and that it is much harder on the cooly than light pruning. The larger the area being cut down, the greater the chance of bad work, and of the work being overlooked, more especially at a time when

economy is a primary consideration, and there may be a tendency to make money go further than usual.

One would lay considerable emphasis on this question of pruning. It is not difficult to foresee a distinct increase in the depredations of borers, bark-eaters, and termites unless care be exercised. There is first of all the tendency to economise. Then comes the tendency to take advantage of the present situation and cut down a larger area. These two propositions are hardly compatible. If expenditure on pruning must be kept down, it should be done by cutting down a smaller area, and still doing it well, and not by endeavouring to prune at a smaller cost per acre. The personal equation will come into this matter, too. In former times the desire to obtain as large a crop as possible was an inducement to get the pruning done in such a way as to make sure of giving the bush every chance to yield. This inducement has now by no means the force it had, for, be as conscientious as one will, it is difficult to give the same care to things which do not matter very much as to those that do, and with coolies in their present unsettled state it is not always easy to press matters.

Economy in cultivation is not likely to do so much harm as economy in pruning, but reducing the number of hoes, or neglecting to fork round the bushes, will undoubtedly result in an increase in the number of those insects which pass some part of their life-history in the ground. Forking and thullying, more especially in termite-infested areas, should be continued as far as possible. The drought of 1919 gave termites an opportunity of establishing themselves very firmly in the tea, an opportunity of which they appear to have taken full advantage, and if forking or thullying be dropped now the results might be serious. By forking and thullying, too, even though they are not collected, the chrysalids of such pests as the looper, sandwich caterpillar, etc., are destroyed in large numbers.

One would rather, speaking strictly as an entomologist, see two rounds of hoeing missed than one round of thullying or forking, not only because of the nature of the operation, but

because of the time of year at which it is done. In places where looper and sandwich caterpillar are of importance as pests, it will be more important than ever, with a reduction in the number of light hoes put in during the season, to keep a constant observation on the behaviour of these insects and arrange, as far as possible, to put in the hoe at a time when the insects are found to have left the bushes and gone into the ground. One thing more, outside the province of the Entomologist, but within that of the Deputy Chief Scientific Officer. This department has for some time advocated that the hoeing of heavy soils in the rain should be avoided as far as possible. What an opportunity for an intelligent application of the true principles of economy !

Reduction in expenditure on manuring will doubtless be almost universal. Such expenditure as is incurred will, or at any rate, should be incurred with the idea, not of forcing high yields from the bushes, but of getting the soil into as good fettle as possible against the time when leaf is to be forced through once more. Attention will therefore probably be directed to the application of phosphoric acid and potash rather than nitrogen. Such a change will be of vast benefit to the bushes, for excessive nitrogenous manuring has a great tendency to increase the liability of the bushes to disease, and there is no doubt that continued nitrogenous manuring is one of the contributing factors to the increase that has been observed in the spread of certain diseases of tea. There is no doubt, either, that nitrogenous manuring will be largely resumed on the return of normal conditions. Nitrogen is necessary if leaf is to be forced through, and one does not revert to beef from an ox fed at grass because the stall-fed ox is more delicate. At the same time, by a judicious use of manures other than nitrogenous during this period of depression it will be possible to counteract many of the ill effects of over-manuring with nitrogen, and to restore to the bushes some of the hardness and resistance to pests and diseases that they possessed before this intensive manuring was undertaken.

This short note may be considered unsatisfactory in that no hard and fast rules have been laid down as to the lines on which crop reduction and retrenchment should be carried out. Conditions vary to such an extent that it is not possible. One can only bring forward points worthy of consideration, the practical application of which must be considered by each planter from his own point of view. One can, however, lay emphasis on a few points :—

Don't let fine plucking be carried out in such a way as to take more out of the bush.

Don't save money on middle and heavy pruning, unless it be done by pruning a smaller area.

Don't dispense with cold weather forking and thullying if it can possibly be avoided.

Don't forget that while a decrease in the amount of cultivation may favour the multiplication of caterpillar and beetle pests, a judicious control over the times at which the hoe is used will do much to mitigate it.

Don't forget, when applying manures, that an opportunity is now afforded for increasing the hardiness of the plants, for which purpose forcing manures are not of value.

E. A. A.

EXPERIMENTS ON MANURING OF GREEN CROPS.

In Quarterly Journal 1920 Part II, page 49, are given the results of manuring of green crops both in the year of application of the manures, and in the following year.

Below are discussed the residual effects during 1920, the third season after application.

The residual effects are very great and it is clear that a single application of certain manures has effected an increase of fertility which will extend over many years.

In the table previously given the sum of the two crops grown in 1919 was given. In the table below, the average weight of one six weeks crop is given in order to show the variation of the crop with the season. All figures of previous years have been very carefully checked, and an arithmetical error which occurred in the Table quoted in Part II, has been corrected.

MANURING.				Crop in tons per acre.		
				1918.	1919.	1920.
Check plots	...	...	...	$\left. \begin{array}{l} 2.75 \\ 2.62 \\ 3.12 \end{array} \right\} 2.83$	$\left. \begin{array}{l} .79 \\ .53 \\ 1.13 \end{array} \right\} .82$	$\left. \begin{array}{l} 0.82 \\ 0.71 \\ 1.38 \end{array} \right\} .97$
Slaked lime	...	800 lbs.	...	$\left. \begin{array}{l} 2.05 \\ \dots \\ 2.45 \end{array} \right\} 2.25$	$\left. \begin{array}{l} 1.04 \\ \dots \\ 1.23 \end{array} \right\} 1.18$	$\left. \begin{array}{l} 1.65 \\ \dots \\ 2.12 \end{array} \right\} 1.80$
Crushed limestone	...	1,200 lbs.	...	2.79	1.15	2.21
Slaked lime	...	800 lbs.	...	3.16	1.38	1.91
Sulphate of ammonia	...	150 "	...	2.95	0.86	1.68
Crushed limestone	...	1,200 lbs.	...	3.16	1.22	2.54
Sulphate of ammonia	...	150 "	...	3.34	1.35	1.61
Carbonate of magnesia	...	900 lbs.	...	3.34	1.44	2.16
Sulphate of ammonia	...	150 "	...	3.34	1.39	1.52
Slaked lime	...	800 lbs.	...	3.07	1.78	2.50
Sulphate of ammonia	...	150 "	...	3.12	1.56	...
Sulphate of potash	...	75 "	...	3.17	1.24	2.05

MANURING.		Crop in tons per acre.		
		1918.	1919.	1920.
Crushed limestone	... 1,200 lbs. }	... 3.53	... 1.85	... 2.39
Sulphate of ammonia	... 150 " }			
Sulphate of potash	... 75 " }			
Slaked lime	... 1,200 lbs.	0.32	1.43	3.01
Sulphate of ammonia	... 150 "	0.35		
SULPHATE OF POTASH	... 8,200 lbs.	0.40		
Crushed limestone	... 800 lbs. }	... 0.74	... 1.81	... 3.66
Sulphate of ammonia	... 150 " }			
SULPHATE OF POTASH	... 8,200 " }			
Slaked lime	... 800 lbs.	2.66	1.13	1.98
Nitrate of potash	... 50 "	2.73		
Slaked lime	... 800 lbs. }	... 2.64	... 2.53	... 3.10
NITRATE OF POTASH	... 2,500 " }			
Slaked lime	... 800 lbs.	3.68	1.34	2.43
Sulphate of ammonia	... 150 "	4.22		
Superphosphate	... 150 "	4.76		
Crushed limestone	... 1,200 lbs. }	... 4.26	... 1.94	... 2.92
Sulphate of ammonia	... 150 " }			
Superphosphate	... 150 " }			
Slaked lime	... 800 lbs.	3.41	2.11	3.39
Sulphate of ammonia	... 150 "	4.00		
SUPERPHOSPHATE	... 8,200 "	4.78		
Crushed limestone	... 1,200 lbs.	... 3.97	... 3.8	... 3.66
Sulphate of ammonia	... 150 "			
SUPERPHOSPHATE	... 8,200 "			

It will be noted that the average crop of 1918 was very much greater than that of 1919. The very wet year was much more favourable to green crops than the very early part of the season 1919. 1920 was quite a favourable season, although not so continuously wet as 1918, yet the 1920 crops are still very greatly less than those of 1918, particularly on the check plots.

The crops have each year been pulled up and removed completely, so that fertility might be expected to decrease slowly from removal of plant foods by the crop. If this were the only factor acting, the check plots should decrease in fertility more slowly than the manured plots from which bigger crops have been removed, whereas the reverse has been the case.

It will be necessary to carry on these experiments for several more years in order to determine whether the reduced crops are due to season only or whether the initial fertility of the freshly broken grazing land has already suffered so very rapid a drop in fertility from being under cultivation.

It is noteworthy that, in spite of the more favourable season, the check plots gave, in 1920, very little more than in 1919, so that one is inclined to the opinion that a very great decline in fertility of the soil has already occurred on these plots receiving no manure.

On the other hand, all the plots receiving lime have shown very marked increases in 1920 as compared with 1919, and if the above assumption is correct, it follows that an application of lime will arrest rapid deterioration of soil under cultivation.

As in previous years, so in 1920 the average of the plots receiving crushed limestone shows an increase (amounting to about 14%) over the average of the plots receiving slaked lime and the same other manures.

In every combination of lime with other manures, we have in these experiments two plots receiving 800 lbs. per acre of slaked lime, and one plot receiving an equivalent of crushed limestone.

In considering the effects of the other manures apart from that of lime, it is therefore quite accurate to take the average of these three plots, and for greater simplicity and ease of comparison the averages are set down in Table II below which gives increases per cent. from each combination of manures over the average crop obtained from the check plots in the same year.

MANURING.			Increase per cent. over check plots		
			1918.	1919.	1920.
Lime only	(equivalent to 800 lbs. slaked lime)		- 14	+ 44	+ 105
Lime	(equivalent to 800 lbs. slaked lime)	}	+ 9	+ 62	+ 110
Sulphate of ammonia	150 lbs.				

MANURING.		Increase per cent. over check plots		
		1918.	1919.	1920.
Carbonate of magnesia	900 lbs.	+18	+71	+95
Sulphate of ammonia	150 lbs.			
Lime (equivalent to)	800 lbs. slaked lime)	-5	+57	+109
Nitrate of potash	50 lbs.			
Lime (equivalent to)	800 lbs. slaked lime)	+14	+100	+140
Sulphate of ammonia	150 lbs.			
Sulphate of potash	75 lbs.			
Lime (equivalent to)	800 lbs. slaked lime)	+49	+81	+153
Sulphate of ammonia	150 lbs.			
Superphosphate	150 lbs.			
Lime (equivalent to)	800 lbs. slaked lime)	-7	+219	+219
NITRATE OF POTASH	2,500 lbs.			
Lime (equivalent to)	800 lbs. slaked lime)	-83	+121	+266
Sulphate of ammonia	150 lbs.			
SULPHATE OF POTASH	8,000 lbs.			
Lime (equivalent to)	800 lbs. slaked lime)	+41	+224	+267
Sulphate of ammonia	150 lbs.			
SUPERPHOSPHATE	8,200 lbs.			

The results in 1918 and 1919 have been discussed in Quarterly Journal 1918, Part IV, page 106, and in Quarterly Journal 1920, Part II, page 48.

It is only necessary therefore to recapitulate that in the year of application (1918).

- (1) lime only produced a small but definite *decrease* in crop.
- (2) applications of potash salts in every case produced a decrease in crop, which in the case of the enormous dose of sulphate of potash amounted to 83 per cent. The plant was in this case very obviously poisoned by the application, and hardly grew at all.
- (3) phosphoric acid (as superphosphate) gave a large increase in crop, the enormous dose producing an effect slightly less than that of the very small dose.

In the second year (1919), results are somewhat irregular (as the crops were poor) but it is clear that :

- (1) the slight bad effect of the lime has disappeared, and a definite good effect has been produced.
- (2) magnesia has given effects similar to that of lime (apparently somewhat better).
- (3) sulphate of ammonia is exercising a slight residual good effect.
- (4) the bad effect of potash has disappeared and a good effect is shown, not very definite in the case of the small quantities, but very great in the case of the intermediate quantity (2,500 lbs. of nitrate of potash), and quite distinct in the case of the enormous dose (8,200 lbs. of sulphate of potash).
- (5) phosphoric acid (as superphosphate) is exercising a definite residual effect, even in the case of the small application of 150 lbs ; while the enormous dose of 8,200 lbs. has given in the second year more than 3 times the crop obtained from the check plots.

In the third year

- (1) the effect of lime alone is such as to produce double the crop obtained from the check plots
- (2) magnesia produces an approximately equal effect. (This would probably be found not to be true on soils containing a high ratio of magnesia to lime).
- (3) sulphate of ammonia and the small dose of nitrate of potash show no effect in the third year.
- (4) Potash even in the case of the small dose of 75 lbs. of sulphate of potash gives a definite residual effect, while the enormous dose has by now resulted in such an increase of fertility that the crop produced was more than $3\frac{1}{2}$ times that from the check plots.

- (5) phosphoric acid (as superphosphate) continues to show definite residual effect, even in the case of the small dose of 150 lbs., while the enormous dose of 8,200 lbs. has produced an effect just equal to that of the enormous dose of potash.

At the time of weighing it was very noticeable that while the crops on the heavy-potash plots were beautifully turgid and dark green in appearance, those on the heavy-phosphate plots were very yellow, had dropped many leaves, and were flowering. No disease was present but these phosphate plots had the appearance of being finished, while the potash plots would certainly have gone on growing healthily.

This "yellowing" due to superphosphate had been noticed before, and had been ascribed to increased acidity of the soil due to superphosphate; but the addition of sulphate of potash also renders the soil very much more acid. The explanation of the difference is more probably due to the well established property of phosphatic manures in producing early maturity, while potash manuring on the other hand delays maturity and increases the period of vegetative growth of the plant. It is just this property of producing early maturity which makes phosphatic manures such a valuable help in producing large green crops in a short time.

The application of such enormous doses would, of course, be economically impossible in commercial practice, and this experiment has been criticized unfavourably on that account.

It should be understood, however, that the study of such extreme cases is of very great theoretical interest. Such enormous quantities cannot be used by the plant as food, but the results increase our knowledge of secondary effects due, often, to the chemical action of the manure on the soil. A great deal of chemical work has been going on in the laboratory in connection with these experiments.

Up to the present the result of this work has been to emphasize the complicated nature of the problems involved, and much

further work will be necessary before any definite conclusion can be published.

Meanwhile the field tests make plain many important points with regard to manuring of green crops, which facts are probably of very wide application on those acid soils of the tea districts which are also deficient in phosphoric acid.

These conclusions confirm those from previous work at Borbhetta not only on leguminous crops but also on non-leguminous plants like jowar, and guinea-grass, and are in accordance with results on similar soils published by the Chemist to the Government of Assam, and are in general accord with agricultural experience anywhere.

Tea shows itself able to withstand acid soil conditions very much better than most other crops, but it is clear that the fertility of our acid soils is increased by liming, and the tea must eventually respond to the improvement. Good results from lime on tea have in fact been obtained.

Conclusions :—For the purpose of growing a green crop it is clear that on soils such as that of Borbhetta.

- (1) Lime even in doses so small as 10 mds. per acre gives a great and lasting increase of fertility; although, immediately after application, there may be a temporary reduction in fertility.
- (2) Phosphoric acid in doses as small as 2 mds. per acre of superphosphate produces a very great increase in fertility on land newly broken up. Even an enormous dose produces no ill effect but an increase in crop practically equal to that produced by the small dose, in spite of the acidity of the superphosphate.

The residual effect even of 2 mds. per acre is distinct though small, while that of a large dose is proportionately greater, but it is certain that the most economical method of application would be at the rate of 2 mds. per acre, repeated annually.

On soils showing less need of phosphate, application could be less frequent.

- (3) Salts of Potash immediately after application appear to have a negligibly small good effect in small doses, and certainly show a marked poisonous effect when applied in large doses ; but the result even of a large dose is to produce very great increase in fertility after lapse of time.

H. R. C.

THE FUNGUS DISEASES OF THE TEA LEAF

BY

A. C. TUNSTALL, B. SC.

AND

S. C. BOSE.

(Continued from 1920, Part II, page 43.)

Grey blight—*Pestalozzia theae* Sawada.

Grey Blight is one of the commonest blights of tea leaf. It is rarely so serious as brown blight which it closely resembles in appearance. It usually attacks the leaves but is also sometimes found on the stem of the tea plant. The portions attacked by the fungus die forming grey patches on the upper surface. These patches when young are brown. Their edges are sharply defined by a ring of deeper brown colour and may often be marked with delicate concentric rings, alternately light and dark brown. The under surface of the leaf does not usually turn grey. The blight first appears on the upper surface of the leaf as minute brownish spots. These spots enlarge and several spots may coalesce to form one large irregular patch. Minute black dots or pustules (the acervuli of the fungus) are often seen, arranged in concentric lines, mostly near the margin of the diseased spot, on the upper surface of the leaf. Sometimes they are scattered irregularly, over both the surfaces of the spot. Some of the dots coalesce to form black crusts.

The black dots, on the diseased patches, due to grey blight are, as a rule, much larger than those of brown blight. Examined by a pocket lens, the dots will be seen as crater-like openings and, unlike brown blight, are never surrounded by any hair. A cross section of a diseased spot when examined under the microscope will show that the pustules are formed underneath

No. 3.

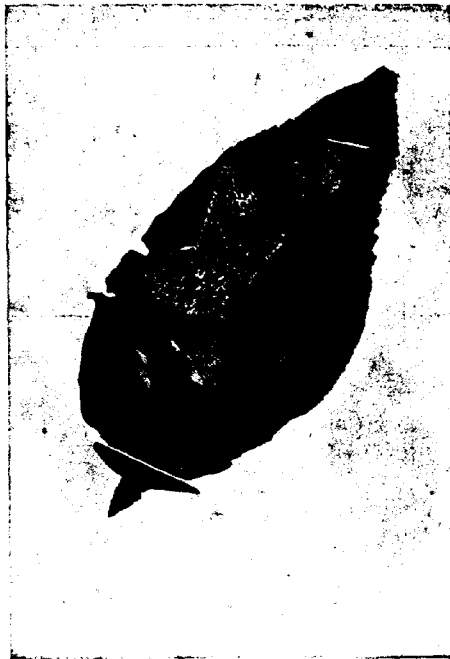
Under surface.



Upper surface.



Two leaves with Grey blight (*Pestalotia theae* Saccaria.)



A leaf with Grey blight. Compare size of the dots with those of Brown blight.

the skin. The pustules arise from a collection of mycelium which develops into bowl or cone-shaped, thin walled spore cases. From the cells of the inner wall of each spore case a stalk grows out and forms at its tip a spindle-shaped cell which is separated from the stalk by a cross wall. These spindle-shaped cells, the spores of the fungus, are further divided by four cross walls into five cells, with the three central ones larger and darker than the single colourless cell at each end. The terminal cell gives rise to 3 or 4 colourless thread-like projections each ending in a blunt knob. These spores, in the course of their development, push their way through by rupturing the skin of the leaf. The spores are distributed by wind, the hair-like projections at their tips acting as floats. Experiments now in progress on the dissemination of the fungus diseases by wind and other agencies, have shown that in the air round about Toeklai, grey blight spores are present in larger numbers than those of other common fungi attacking tea. The mycelium of the fungus grows between the cells of the leaf and within them. It is very fine and colourless and with many divisions.

The fungus grows readily in culture. It grows well in jelly made with either Maize, meal or standard dextrose.

In culture the spores germinate by giving out one or two thin hair-like tubes (germ tubes) usually from the basal dark coloured cells, though they may also germinate from the terminal dark coloured cell or from both at the same time. The cells before germination swell, becoming almost round and lighter in colour. The darker coloured wall then bursts and one or two germ tubes emerge from the sides. Occasionally, the basal colourless cell grows out as a germ tube from the end of the lowest dark-coloured cell. These germ tubes at once branch and form transparent mycelium with divisions. The spores germinate readily.

In culture the mycelium is at first colourless, but 8—10 days after inoculation it becomes cream coloured. The acervuli are formed from 14—20 days from the germination of the original spore. The spores are exuded from the acervuli in black drops,

which when dry form crusts over the acervuli. The spores measure $22.5 \times 7.5\mu$ (1000ths of a millimeter).

The fungus infected cut shoots of tea in 3 days and produced spores in 8 days.

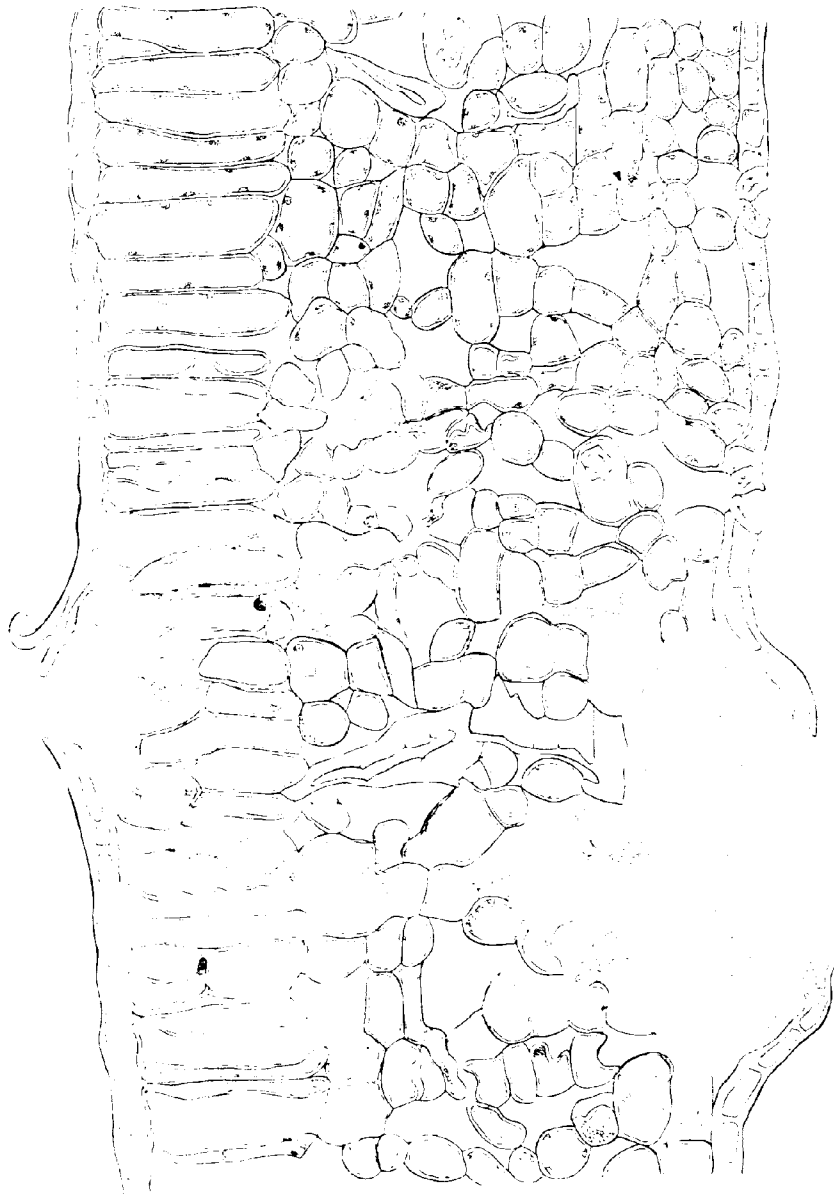
The fungus may attack any tea leaf, but it does not attack vigorous healthy leaves. It usually confines its attack to old damaged bushes or to those previously weakened by some other cause. For example after a hot dry weather the fungus frequently attacks the margins of young, immature leaves and is one of the causes of rim blight. Attacks of red spider also make the leaves susceptible to this disease.

Experiments were made to determine the longevity of spores by storing the diseased portions of the leaf in various ways.

It was found that like brown blight exposure to sunshine was fatal to this fungus within a few months, but under ordinary circumstances, *e.g.*, light shade and a damp atmosphere, it could survive the cold weather, when in dead material. It is therefore necessary to remove all diseased material from the tea and bury it in trenches or hoe it in so deep that it may not come up in subsequent light hoeings.

THE TREATMENT OF THE DISEASE.

The same treatment as recommended for brown blight should be carried out in this case.



A diagram showing the effect of Grey blight on the same section of leaf illustrated in the first part of this series of articles. Note the fructifications of the fungus and the destructive effect of the fungus mycelium on the tissues of the leaf.



A photo-micrograph of a section through a Grey blight spot.

REPORT OF THE JORHAT EXPERIMENT STATION FOR THE YEAR ENDING 31st MARCH, 1920.

This and similar reports for previous years give an account of manurial and other experiments on a typical naturally infertile acid soil of Assam. Since the soil is so infertile it has often happened that the crops obtained, even with the aid of manuring, have been not worth weighing when weather conditions were unfavourable. The experiments also have been conducted on single plots only, and on a soil so patchy and sensitive to small local variations in the efficiency of the drainage, it is therefore impossible to quote numerical results with any degree of accuracy. However the experiments have now been carried on over a period of 11 years and very useful results have been obtained which distinctly advance our knowledge of methods of improvement of such soils.

1. *Soil Toxin*.—The most noteworthy feature of this soil is its acidity. The annual reports on the Farm have for many years stated : " We are now in position to state that the sterile condition of the soil to most crops in the cold weather and also to certain crops in the rains is due to the accumulation of acid substances, *among them being a specific toxin* which has been isolated and experimented with in culture solutions with effects on the plant's root system and growth precisely similar to those observed in the field ; these are readily neutralised and rendered harmless by dressings of lime or other base to the soil."

It is possible, therefore, that the results obtained may not apply to all acid soils, but only to soils containing a toxic acid similar to that which has been isolated by Meggitt. Unfortunately no information has yet been published on the nature and method of isolation of this toxin, although interesting notes on its manner of action on plants were given in " *Studies of an Acid Soil in Assam*," published in 1914. However it is probable

that very many acid soils do contain a similar toxin, particularly those which suffer from lack of aeration due to deficient drainage, and the results obtained at Jorhat are probably of fairly wide application.

2. *Lime*.—As would be expected, the most marked improvement in the soil follows the use of lime, and in fact without lime any improvement at all is small, and at the best very slow.

The experiments have proved

- (i) that the benefit from lime is not due to requirement by the plant of additional lime as food, since unless added in a form capable of reducing acidity (slaked lime or crushed limestone) the good effect is not obtained. The sulphate or chloride, for example, produce no good effect.
- (ii) That the good effect of lime is due primarily to its power of neutralizing acidity is proved by the fact that magnesia, soda or potash are equally effective. On this soil which contains very little clay there is not even any appreciable improvement in tilth, such as commonly follows the use of lime on soils containing more clay.
- (iii) Up to 60 mds. of slaked lime per acre in one dressing can be applied with advantage on this soil.
- (iv) The effect of lime is very lasting. A plot receiving 50 mds. per acre 11 years ago still shows a very great advantage over a check plot otherwise exactly similarly treated and cropped; but this advantage is gradually decreasing year by year.
- (v) It is better to apply small dressings of lime frequently than large dressings at longer intervals, although the plots receiving the larger initial dressings gave better crops during the first few years. For example, 10 mds. per annum for six years have given better *average* crops than 60 mds. in one dose, or two doses of 30 mds. at three years, inter-

val, now that cropping has been carried on over a period of nine years. No lime has been applied in the last 3 years. Results from the smaller, more frequent dressings have been better since the fifth year of the experiment.

- (vi) "The evidence is overwhelming that for most ordinary farm crops, be they deep or shallow rooted, it pays not to incorporate the lime too deeply." In this case the trial was on the effect of ploughing in the lime 3 to 4 inches deep, as against 7 to 8 inches deep. The results over 7 years are greatly in favour of the former, although deep rooted crops like Arhar at first did better with the deeper cultivation. The reason for the more favourable effect of keeping the lime near the surface is apparently that it washes down (and away) quite fast enough. The bringing up of this particularly infertile subsoil may also be affecting results, although when no lime was applied the growth of Cowpeas and Arhar was better on the plot which had been more deeply cultivated.

3. *Phosphoric Acid*.—Phosphoric acid is clearly of importance second only to lime on this soil. Its action has always been great on a mustard crop, but the effect has often been marked (*e.g.* on the cane crop) by the fact that the plots not receiving the special dressings of purely phosphatic manure were receiving cattle manure, or other manurial mixture which provided sufficient phosphoric acid for the crop's requirements. It is also noted that in some cases the additional growth of weeds produced by the use of bonemeal reduced the weight of crop. This growth of weeds is a tribute to the fertilising value of phosphates on this soil. Finely ground rock phosphate (Stane's Flour Phosphate) has proved to be of value on this soil, but no attempt has been made to form an estimate of its efficiency compared to more expensive phosphatic manures.

4. *Organic Matter*.—Addition of organic matter has also been shown to be valuable as a means of soil improvement. The effect of cattle manure has been consistently good. Cattle manure with lime has proved a sufficient dressing to grow the majority of crops ; and even when used without lime, the effect of continual heavy dressings is that the land produces heavier and heavier crops, though little improvement was observed from the use of cattle manure alone when the land was first broken up. This good effect of cattle manure cannot, of course, be ascribed to its mere bulk of organic matter, since it provides also every necessary plant food, particularly phosphoric acid which is of such great value on this soil. The effect of green manuring has generally been good. Laboratory experiments have shown that the effect of green manuring has been to increase the percentage of nitrogen in the soil. In spite of this, during the year covered by the report, the aggregate yield from the green manured area was slightly less than the yield from the area not green manured.

On this point the Agricultural Chemist observes : “From personal observations during the growing period of the crops, I am convinced that this result is due to waterlogging, which occurred to a greater extent on the green manured area.”

There can be no doubt that the provision of efficient drainage is at least as important as any manurial treatment to soils like that of the Jorhat Government Farm.

It has been emphasised in previous issues of this Journal that green manuring is likely to prove disappointing on land inefficiently drained. Indeed no manurial treatment exercises its full effect when the soil is much above its optimum water content.

In addition to the above information with regard to the soil's increase in fertility with treatment, much other information has been obtained with regard to crops...trials of varieties of sugarcane, pulse crops, and fodder crops, for which planters interested should consult the original reports. Since, however, indigo is now arousing interest, it is worth noting that a trial of

indigo in 1917 showed that while the crop on the unlimed land died off while young, the limed area did very well and set a fine crop of seed although a heavy hailstorm just previous to ripening reduced the crop of seed to only 254 lbs. from the acre. It is recorded that in the following year the plants were cut down and gave a good crop of green stuff.

H. R. C.

INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING THE SEASON 1920.

A perusal of the entomological reports received from the tea districts during 1920 suggests a rather startling question. What has become of green-fly? In not a single instance is green-fly reported as having been noticed. To be sure, the reports are incomplete, and though they are all from the Surma Valley, where the energetic efforts of the Secretary to the Surma Valley Branch on our behalf, which we cannot sufficiently acknowledge, appear to have borne fruit, yet green-fly has always been reported from the Surma Valley before. At Tocklai the pest was very much in evidence, and it was to be seen at most places in Cachar, Sylhet, and the Duars. Nowhere, however, was the damage done very conspicuous.

The year 1920 must be put down as one in which green-fly did very little damage, and yet their numbers seemed to be as great as usual. This is but another instance pointing to the probability of the condition of the bushes, rather than the numbers of the insects, being the factor which must be studied in devising means of control.

Mosquito blight, during 1920, was more serious in the Duars than in 1919, less so in the Surma Valley and in Assam. There is little doubt that the rainfall has a considerable influence in bringing about these peculiarities in the general distribution of the insect, and that attention to drainage, with a view to minimising the effect of variation in rainfall, is of primary importance. The Brahmaputra and Surma Valleys generally behave similarly to one another as regards mosquito blight, and entirely differently from the Duars and Terai. The rainfall curves for the two former valleys are similar in character, and of a distinctly different type from those of the latter districts. The connection, when the mass of other evidence is taken into consideration, is not far to seek.

The peculiar disease called by Munn the Cachar Stalk-killing Mite showed up very much in the early part of the season, more especially in the Surma Valley.

Other pests received at the laboratory for report, but not referred to in reports from districts, were *Scirpa assamensis*—

2 INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING SEASON 1920.

Brenske, the beetle which "skeletonises" the leaves of a few odd bushes at about April, which was received from the Terai, and the caterpillar of a *Lymantriid* moth, probably *Leucoma submarginata*, found on tea in Sylhet in February.

Caterpillar pests were not conspicuous in 1920.

The notes are, as usual, incomplete. This is inevitable. The Surma Valley has responded to the call for monthly entomological reports, and even there the reports are not complete, but the other districts have not obliged at all. Of the books of 24 report forms referred to in the corresponding report of last year (Quarterly Journal for 1920, page 27) not one has been applied for.

Appended are diagrams showing the nature and extent of insect damage on gardens from five sub-districts in the Surma Valley. No. II is perhaps not quite characteristic for the sub-district, as the garden from which the reports were received is wholly a teela garden.

I.—LUKHIPUR.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Orange beetle	...											
Red borer											
Gelatine grub	...											
Faggot worms	...											
Looper											
Tea tortrix ^o	...											
Tea mosquito	...											
Tea aphid											
Crickets											
Termites											
Red spider											
Pink mite											

^o Several different insects are possibly confused here.

INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING SEASON 1920. 3

II.—HAILAKANDY.

[illegible]

III.—SYLHET.

[illegible]

IV.—SOUTH SYLHET.

[illegible]

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V.—NORTH SYLHET.

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Tea mosquito	...												
Red spider	...												

CRICKETS.

(*Brachytrypes achatinus*—Stoll.)

This pest is twice recorded—from one garden in Cachar and one in Sylhet. In the former case the insects were first noticed in February, present in the greatest numbers in March, and gradually decreased after that time, until by July they had disappeared. The damage to the tea was apparently negligible, but green manures were seriously damaged. The Sylhet garden reported a slight attack in October. On the whole, crickets appear to have done less damage than usual in 1920.

ORANGE BEETLE.

(*Diapromorpha melanopus*—Lacord.)

This pest is generally to be seen throughout the year. Evidence is afforded by reports from Cachar of the occurrence of broods of the insects, resulting in the appearance of adults in March to April and again in July and August.

TEA MOSQUITTO.

(*Helopeltis theivora*—Waterh.)

The behaviour of this pest during the season 1920 was of considerable interest. In Assam, on the whole, the pest was not so serious as usual, certainly not as serious as in 1919, yet in the Doom Dooma district it attained considerable dimensions during the latter part of the season. In Cachar and Sylhet, also, the damage done is described as not so serious as in the previous year, though reports from Hailakandy describe the attack as more so in 1920. A curious feature of the attack in the Surma Valley was

the way in which the depredations of the insect fluctuated during the early part of the season. Serious damage is reported in many instances so early as April, but the attack lifted again in May, came on again in June, to show a tendency to lift later, which tendency in some cases continued to the end of the season, but in others disappeared in September and October, when the insects again began to do a certain amount of damage in places.

The pest was, for the first time, reported from the Luskerpore Valley, from one garden, where it first appeared at the end of September.

In the Duars mosquito blight was very serious, more especially in the Chulsa and Hantapara districts.

The behaviour of the insect during the past season was very irregular, and several instances occurred where tea which was shut up by the pest in June and July was found to have come through, and to be waving in leaf in August. This occurred only when the tea had been left alone, and practically abandoned for the time being.

One fact worthy of placing on record in connection with the past season is the fact that leaf returns cannot, as is usual, be taken as a rough guide to the amount of damage done by the pest, considerable decrease in outturn shown by many mosquito blighted gardens being very largely due to alteration in the style of plucking.

TEA APHIDS.

(*Cyclonista theaeicola*—Buckt.)

Slight attacks of this pest were, as usual, general during the early part of the season (February to May). The reports make no mention of attacks in nurseries, though these must have occurred. They show, however, that in the case of old tea the pest is most noticeable on low pruned and cut back. Phenyle solution is reported to have been used successfully against the pest, but the strength was not stated.

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BUNCH CATERPILLAR.

(*Andraca bipunctata*—Wlk.)

This pest is so common and so easily dealt with as to escape notice in the reports, but one garden in Sylhet reports conspicuously large numbers of the pest in May and June on which 100 children appeared to make no impression by steady daily collecting. The caterpillars disappeared at the end of July, and reappeared in small numbers in September and October.

RED BORER.

(*Zeuzera coffeae*—Nieth.)

The depredations of this pest became noticeable in Cachar in August, and from then till the end of the season the brown dead shoots were to be noticed in the tea. In the Assam Valley the pest behaved similarly.

BARK-EATING BORERS.

(*Arbelus* Spp.)

The depredations of these insects are, as usual, reported only from Cachar, where the damage done is gradually becoming less serious. It is regrettable that during the present crisis many gardens which were gradually getting the better of these pests may, owing to the necessity for retrenchment, go gradually back to their former state.

GELATINE GRUB.

(*Belippa* Spp.)

This insect appeared in sufficient numbers to be noticed in Cachar and South Sylhet in October, disappearing again in December.

TEA TORTRIX.

(*Homona menisiana*—Wlk.)

Appeared in Cachar during the end of March and the beginning of April, but odd individuals were noticed throughout the year.

LOOPER.

(*Biston suppressaria*—Guen.)

A serious attack was reported from the North Bank in April. In the Hailakandy district of Cachar the pest was noticeable in April-May, and again in June and July, and is reported from Lukhipur in October and November.

FAGGOT AND BAG WORMS.

(*Clania* Spp.)

Reports from Cachar indicate that these were less in evidence than usual. Reports were not received from other districts, but specimens were received from Darjeeling.

CONICAL PSYCHID.

(*Psyche assamica*—Watt.)

This pest is reported to have been noticeable on a garden in Cachar in March and April.

TERMITES.

This pest is reported from one garden in Cachar as having continued to do damage to young tea throughout the season. In the majority of instances, however, the pest ceased to be conspicuously active above ground towards the end of May, and begun to appear again in August. In Assam termites did less damage, on the whole, than during the previous year. Forking round the bushes is reported to have a distinct deterrent effect on the pest.

RED SPIDER.

(*Tetranychus bioculatus*—W.-M.)

Throughout the tea districts the attacks of red spider were much less intense than usual, especially in the Surma Valley. The good start to the season is probably a sufficient reason for this. A slight attack was noticed in some places towards the end of the season in October, notably in South Sylhet. Sulphur, lime-sulphur, and cow-dung, sulphur, and mud, are all reported as

8 INSECT PESTS OF TEA IN NORTH-EAST INDIA DURING SEASON 1920.

having been used against the pest. One or two planters seem to have regarded the efficiency of treatment with sulphur as doubtful.

PINK MITE.

(*Phytoptus theae*—Watt.)

Attacks of this pest in North Cachar were less serious than during 1919.

CACHAR STALK-KILLING MITE.

This is reported from only one garden in Cachar, though during the year specimens of the disease commonly attributed to this mite were received from all districts from Makum in Upper Assam to South Sylhet. This disease is especially noticeable during the early half of the season, and results in the branches and shoots developing an appearance very much like that of canker. Lime-sulphur solution, sprayed onto the bushes, was used with success as a remedy for this disease in Sylhet.

E. A. A.

NOTES.

Spraying Experiment with Nitrate of Potash.—Very largely increased growth has been obtained experimentally as a result of spraying the leaves of tobacco with nitrate of potash ; and it was thought worth while to make a trial on a small scale with tea.

It was hoped that the result of the application might not only give largely increased crop but might assist in decreasing the liability of the leaf to blight, since the increased growth obtained with tobacco had been ascribed to actual absorption of the salt by the leaf.

Twelve rows of very even tea were set aside for this experiment.

The first row was sprayed fortnightly, beginning in July with 10 gallons 1% nitrate of potash solution per 100 bushes.

The second row received no treatment.

The third received the same amount of solution as the first row, but it was applied to the soil only, and not sprayed on to the leaves. The object of the third row was to determine how much of any benefit found from spraying might be ascribed to the mere manurial effect of the solution. As the nitrate of potash was applied at the rate of about 17 lbs. per acre at a time, some benefit from manuring might be expected, in the course of the season, although the amount applied in one application is negligibly small.

The remaining nine rows allowed for three repetitions of each of the above treatments.

Average yield in ounces green leaf per 100 bushes.

Sprayed.	Untreated.	Manured.
1,037	1,046	1,025

The results show no differences beyond experimental error, though as the sprayed lines were slightly the better to start with,

it is probable that the spraying has done some harm, but very slight harm. Brown blight was, considering the season, fairly bad on this plot; and it appeared from observation that the sprayed bushes were slightly more attacked than the unsprayed.

Spraying with nitrate of potash, then, cannot be recommended as a treatment for tea, either for increasing the rate of growth or for decreasing blight attack.

The tea used had been cut down the previous cold weather, so that the spraying was on young growth, which might be expected to react better to such treatment than old leaves.

H. R. C.

Flour Phosphate.—A sample of flour phosphate submitted to the Department has shown the following average analysis:—

Iron and Alumina	...	12 %
Lime	...	56 %
Magnesia	...	trace
Phosphate total	...	26 %
Phosphate	...	6 %

Manures previously on the market under this name frequently contained the phosphoric acid as the practically unavailable iron and aluminium salts. The analysis of the above sample shows it to be a calcium phosphate.

The availability was tried against bone meal at Boribhetta. Nine plots of cowpeas were put out late in October and the crops were gathered six weeks later. Three plots were treated with bone meal, three with an equivalent quantity of flour phosphate and three were check plots. On the total crop, flour phosphate gave 16 % and bone meal 24 % increase on the check plots. The value of these figures is somewhat detracted from when the variation of the individual plots, and the pooriness of the growth (owing to complete absence of rain) is considered. From appearance, however, it was quite clear that the flour phosphate had an immediate effect on the crop, and for green crops is probably a better manure at the price than bone meal.

H. R. C.

TRIAL OF NITROGENOUS MANURES ON TEA.

The plots for this trial were laid out and planted in 1916 with this particular experiment in view, and from the beginning everything possible has been done to make and keep them even.

In spite of this, it was soon clear that the initial fertility of the soil varied so greatly on different plots that one could only hope for an approximation to accuracy by averaging over a number of plots receiving the same treatment. Of the eighteen plots three, therefore, were used as check plots, while the remaining fifteen provided 5 sets of 3 plots each, and each of these 5 sets received a different manure.

At the end of 1918 the plants were collar pruned, and grew so badly in 1919 that an average of only $1\frac{1}{2}$ maunds pucca tea per acre was obtained. As each plot contained only 54 bushes, the error in the plucking and weighing of the leaf obtained at each plucking exceeded the difference between the plots, and in that year therefore no figures were obtained which could be considered of any value for measuring the initial fertility of the plots.

The tea having been left unpruned, yields were better, so that the error of weighment could be disregarded, and the yields obtained in 1920 up to the end of May are taken as indicating the initial fertility.

There were no vacancies, but there were a few infillings, and weak bushes, which were left unplucked from the beginning of the season. In calculating yield per acre these are allowed for.

The manures were applied at the end of May.

The manuring was as follows :—

MANURE PER ACRE.					Nitrogen per acre lbs.	Phosphoric acid per acre lbs.
1	Check	Bone meal	... 162 lbs. ...	...	5.6	35.6
2	{	Nitrate of soda	... 212 " ...	...	30.0	Nil.
		Bone meal	... 162 " ...	...	5.6	35.6
3	{	Sulphate of ammonia	... 150 " ...	...	30.0	Nil.
		Bone meal	... 162 " ...	...	5.6	35.6
4	{	Mustard cake...	... 704 " ...	...	32.7	17.6
		Bone meal	... 82 " ...	...	2.9	18.0
5	{	Nitrox	... 320 " "	...	32.0	12.8
		Bone meal	... 104 " ...	...	3.6	22.8
6	{	Green jungle	... 3 tons ...	...	30.0 approx.	Nil.
		Bone meal	... 162 lbs. ...	...	5.6	35.6

The plots receiving nitrogenous manures thus each received exactly 30 lbs. more nitrogen per acre than the check plot and the same quantity of phosphoric acid, except in the case of the plot receiving the green jungle. This was originally sown with sunn hemp, and it was expected that here also the nitrogen added as green stuff would not differ greatly from 30 lbs. Unfortunately the green crop failed completely owing to attack by a root disease (which fortunately does not attack tea). After seven weeks' growth the green crop was abandoned as hopeless, and the crop (averaging less than half a ton per acre) was made up to 3 tons per acre with green jungle, thatch, phutuka (*Melastoma*) and boga medeloa, this being cut from neighbouring waste land, wood being up to finger-thick.

This was very lightly hoed in on July 17th.

This last set (6) therefore must be considered as a trial of green jungle as manure. Its action differs from that of a green crop since there is no suffering of the tea while the crop is growing. In this case, of course, a crop was growing, but it was so poor that the total growth on the green-manured plots hardly exceeded that of the jungle on the other plots, and it is considered that the loss in tea crop from the growth of the green

manure was in this case practically negligible. With favourable (wet) weather, however, it was shown at Heeleaka that the bad effect of a green manure while growing is not very great, and the result from this, set 6, may therefore be considered to give some indication of the probable efficiency of a green crop.

The actual weights obtained are recorded below in order to show how uneven were the plots, and also to show that there was no great difference between the averages of any three evenly distributed plots. The weights look small, but the average plucking yielded about 2 lbs. from a plot and as weighment was certainly accurate to half-an-ounce the possible error from weighment cannot exceed $1\frac{1}{2}\%$, and with 40 pluckings errors in weighment are probably negligible.

Actual weight of leaf in lbs. and ozs. from $1/50$ acre plots:—

				To end of May before manuring.	June to November after manuring.
1	Check plots	...	...	$\left\{ \begin{array}{l} 11.6 \\ 12.5 \\ 9.15 \end{array} \right\} 11.3$	$\left\{ \begin{array}{l} 49.3 \\ 46.13 \\ 42.8 \end{array} \right\} 46.3$
2	Nitrate of soda	...	...	$\left\{ \begin{array}{l} 9.7 \\ 11.11 \\ 11.14 \end{array} \right\} 10.13$	$\left\{ \begin{array}{l} 49.7 \\ 53.9 \\ 47.4 \end{array} \right\} 50.1$
3	Sulphate of ammonia	...	...	$\left\{ \begin{array}{l} 10.0 \\ 11.14 \\ 9.8 \end{array} \right\} 10.7$	$\left\{ \begin{array}{l} 47.6 \\ 50.10 \\ 42.8 \end{array} \right\} 46.13$
4	Oilcake	...	...	$\left\{ \begin{array}{l} 10.15 \\ 10.1 \\ 10.15 \end{array} \right\} 10.10$	$\left\{ \begin{array}{l} 44.2 \\ 46.5 \\ 46.12 \end{array} \right\} 45.12$
5	Nitrox	...	...	$\left\{ \begin{array}{l} 11.7 \\ 10.6 \\ 11.10 \end{array} \right\} 11.2$	$\left\{ \begin{array}{l} 47.3 \\ 45.14 \\ 44.5 \end{array} \right\} 45.13$
6	Green jungle	...	...	$\left\{ \begin{array}{l} 16.3 \\ 9.9 \\ 8.8 \end{array} \right\} 11.7$	$\left\{ \begin{array}{l} 65.5 \\ 43.15 \\ 40.3 \end{array} \right\} 49.13$

The differences in total crop look very small, but can be better judged when calculated to weight per acre.

In the following table allowance has been made for the bushes left unplucked :—

Lbs. Green leaf per acre.

	To end of May, average before application of manure.	June to November, average after application of manure.	Increase over check plot lbs.
1 Check plot ...	598	2,465	22
2 Nitrate of soda ...	579	2,689	224
3 Sulphate of ammonia ...	577	2,585	120
4 Oilcake ...	574	2,456	.....
5 Nitrox ...	602	2,473	8
6 Green jungle ...	634	2,763	298

These increases cannot be considered as indicating the value of the manure, since the plots were not equal before the manure was applied.

The yield from the check plots from June to November is 4.12 times the yield from March to May. It is probably fairly accurate to assume that had no manures been applied the other plots would have increased at the same rate. By making this assumption we may calculate what the yield without manure would have been, and the difference between this calculated yield and the actual yield probably gives the best index to the efficiency of the various manures, obtainable from these experiments.

	Yield to end of May	Actual yield June-November.	Calculated yield if no manure had been applied	Increase per acre in lbs. green leaf.	Approximate cost per acre of increase.
Nitrate of Soda ...	579	2,689	2,390	299	Rs. 27.0
Sulphate of ammonia ...	577	2,585	2,377	208	" 27.0
Oilcake ...	574	2,456	2,365	91	" 20.8
Nitrox ...	602	2,473	2,480	...	" 17.8
Green jungle ...	634	2,763	2,612	151	Labour only

From this we can calculate the increase per cent. due to the manures. While no pretence to exactitude is made it is believed that these figures do give a fair idea of the relative efficiency for tea of the various manures in the year of application.

Nitrate of soda ...	...	12½ %
Sulphate of ammonia ...	...	8½ %
Green jungle ...	...	6 %
Oilcake ...	...	4 %
Nitrox ...	...	0 %

but the results calculated from these figures can be corrected by a study of the curves.

The smallness of the effect of the manuring may be a matter of surprise, particularly as this tea at the time of application showed every indication of requiring manure. In 1919, plucking at 27" after collar pruning, the yield from the check plots was only 1¼ mds. pucca tea per acre, and the appearance of the plots up to the end of May 1920 was extremely miserable, Brown blight being bad. From June onwards very great improvement set in and 9½ maunds was obtained from the check plots in 1920 (unpruned). The disparity is much greater than can be explained even by the very great difference in the two seasons. In 1919, 10 maunds slaked lime per acre had been applied. It is probable that the effect of this in the year of application was to reduce crop, while in 1920, the effect was favourable. Even so, this soil is markedly deficient in phosphoric acid and it is probable that all plots including the check plot benefited from the application of bone meal.

The combined effect of the lime and bone meal possibly allowed more rapid production of nitrates from the soil organic matter, so that the effect of added nitrogen was less marked than usual.

However, it is believed that the effect of such small doses of manure as are generally used in tea is not normally much greater than that obtained in this experiment. If so, it is clear, that manuring generally is not a paying proposition in the present state of the tea market, except in the case of such manures as cost little

or nothing beyond the cost of labour for which, at times, there may be no other use. Such manures are Green jungle, Bheel soil, and to a great extent Cattle manure and Green crops.

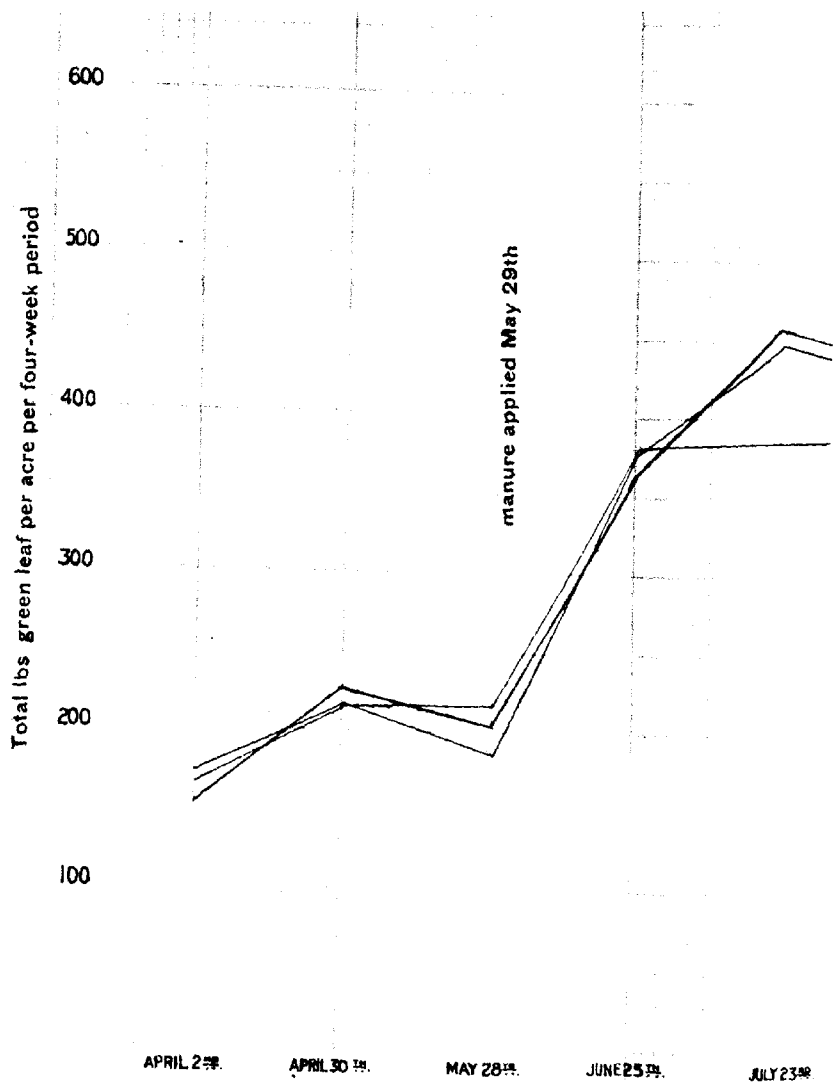
Such manuring is strongly recommended even in view of restricted crops. Finer plucking alone will, in many cases, do all the restricting necessary. In extreme cases where the plucking system is changed to taking strictly 2 leaves and a bud, instead of an average 3 leaves and a bud or more, the restriction would probably be nearer 50% than 20% unless the number of rounds of plucking could be increased effectively.

Nor need the smallness of the results from this experiment be discouraging. If there is any residul effect from manuring on the yielding capacity of the bush (and that can hardly be doubted), then continuous manuring will increase yielding capacity in a compound ratio. An increased efficiency of 5% per annum would double the yield in 15 years.

The characteristics of each manure are commented on separately below, and the rapidity with which each comes into action is traced from curves obtained by plotting the total yields per acre obtained in each period of four weeks against time in weeks. It will be seen that the application of manures coincided with the beginning of a very sudden increase in the rate of leaf production. This sudden rush of leaf was due mainly to the very favourable weather of June, but the jump was much more marked than on unmanured plots and is possibly partly accounted for by the action of the bone meal which all plots, including the check plots, received.

Rapidly available manures :—A study of Fig. 1 shows that both the nitrate of soda and sulphate of ammonia plots had averaged slightly lower yields than the check plots before the manure was applied.

During the four-week period following application the sulphate of ammonia had shown no result and the nitrate of soda only a very small relative increase. In the second four-week period both manures gave a very marked increase in leaf and this was



However, it is possible that some other factor, such as the sulphate of ammonia was coming into play, and the effects

maintained in the third and fourth periods, although both, and particularly sulphate of ammonia, showed a falling off.

In the fifth period nitrate of soda fully maintained its advantage, but the falling off in effect of sulphate of ammonia was more marked. In the sixth and last period nitrate of soda still shows an increase, while the sulphate of ammonia plots gave even less than the check plots.

If these experiments have any accuracy at all, this greater efficiency of nitrate of soda towards the end of the season is significant. The season was certainly much more favourable to the use of nitrate of soda than the average season in Assam, because the rainfall was small ($67\frac{1}{2}$ inches) and very well distributed. Hitherto this department has been, with reason, very shy of advising the use of nitrate of soda in the tea districts. Until recently its price compared very unfavourably with that of other manures; and as it is known to be very readily washed out of the soil, it could not be recommended against other manures less liable to loss. Experiment in future years may show that this attitude is justified in many seasons.

But no consideration of favourable season can explain its greater lasting effect compared with sulphate of ammonia. As far as the nitrogen contents are concerned nitrogen as nitrate is known to be less lasting than nitrogen as ammonia. The lasting effect of the nitrate of soda must be attributed to some constituent other than the nitrogen. Potash is known to increase the period of vegetative growth of a plant. This particular sample of nitrate of soda (the purest then available) was found by analysis to contain 5% potash, and thus the manure applied added 10 lbs. of potash per acre to the soil. This added potash was probably reinforced by additional available potash liberated by the nitrate of soda from the soil minerals. The potash so supplied probably stimulated vegetative growth of this unpruned tea, at a time when it was inclined to go "banjhi."

However, it is possible that some adverse secondary effect of the sulphate of ammonia was coming into play, and the effects

of these two manures in future years will be watched with interest.

Slow Acting Manures :—A study of the curves shown in Fig. 2 shows that the effects of the nitrox and of the oilcake were very similar. The two curves run practically parallel and are not widely separated for the whole of their lengths. Since however the oilcake curve starts somewhat below that of nitrox and in the last eight weights is very slightly above it, it may be concluded that the action of oilcake was slightly more favourable than that of nitrox.

Neglecting the first four weeks' pluckings both curves start definitely below that for the check plot, from July 23rd become practically the same curve, and only show a definite superiority on October 15th, twenty weeks after the manures were applied, and that superiority is very slight.

Nitrox is a mixture of sinews and hoofs and horns, crushed and torn into as fine a state of division as such material can reasonably be expected to attain. Similar are Nervox, Ligox, Musclox, and Sinox, though the last-named is generally supplied in unduly large pieces, and also contains biggish lumps of bone.

Such manures as these do not readily decompose, and must always be comparatively slow acting, but that they should show practically no result at all is certainly surprising. If such manures are to be of any use at all they must be used in larger quantities and must be applied as early as possible, February, or even January to allow time for decomposition.

Much more surprising is the hardly less marked failure of oilcake. The particular sample used was purchased in the local bazaar, and was obviously a good specimen of "country" oilcake. Its analysis was good—4·7% nitrogen—and no adulteration could be suspected. It, however, was much more oily than average samples, and on analysis was found to contain 15% of oil. This high percentage of oil is the probable reason for its low availability.

Previous experiments with oilcake have given very definite results in the year of application.

All these plots, after cutting across at 24", will be plucked next year without further manuring, and sufficient yield is expected to determine residual effects of the manures. It is expected that both nitrox and oilcake will show up ; but if decomposition is very slow, it is possible that at no time will there be a sufficient increase in the concentration of nitrates in the soil to produce any definite increase in crop.

It is possible, however, that the comparative inefficiency of these manures does not lie wholly in the insoluble nature of their nitrogen compounds.

Both these manures contain phosphorus compounds, and in order that all plots might receive the same quantity of phosphorus, the quantities of bonemeal applied to these plots were less than were applied to all the other plots including the check plots. Now available phosphoric acid has a very great effect on this soil ; and it is possible that the failure of nitrox and oilcake may not be due only to the comparatively less available forms in which they contain their nitrogen, but largely to the inefficiency of their phosphorus compounds.

Both, however, are generally cheaper per unit of nitrogen than readily available manures, even if no allowance is made for their phosphorus ; and at the next application of manure their phosphorus contents will be ignored.

Green Jungle :—(See Fig. 3.) Starting definitely above the check plot, the yield for the green jungle plots retains much the same relative position during the seven weeks following the application of bonemeal and growing of the green crop, indicating that the effect of the growth of the small green crop was slight.

Following the hocking in of the 3 tons per acre of green stuff on July 17th, the rise in the yield is almost immediate. The effect of the green stuff was in fact more rapid even than that of nitrate of soda. The green stuff was of course applied at a

season when the effect would be expected to be more rapid. Temperature and soil moisture were both very favourable.

The mechanical effect on the physical condition of the soil must also have been very great. *Green jungle* would of course be expected to prove more efficient than nitrate of soda, since it supplies not only nitrogen, in a form here shown to be very efficient, but also organic matter, and additional phosphoric acid, lime, and particularly potash. Applied as it was, the top few inches of soil rapidly became a much improved medium for the growth of beneficent soil organisms.

The calculated increase of 6% in the season is small only because the manure was applied so late in the season. Such manure has previously generally been used in trenches. The present experiment shows that green stuff may be used as a top dressing, and is likely to be very efficient as a manure for cut-back tea.

H. R. C.

THE EFFECT OF MANURES ON THE CONSTITUTION OF THE TEA PLANT.

Manures are applied to tea gardens for various reasons—the production of increased crop, the improvement of the soil, the helping of bushes through a blight attack, the growing of wood on cut-back tea or the production of root-growth to shallow-rooted bushes. Seldom, however, is manure added with the idea of directly improving the quality of tea. As a matter of fact very little is known in this connection, although Mann and others quote figures indicating that nitrogen in excess produces poor quality tea and that potash and phosphorus manures produce good teas.

The quality of tea is a very elusive factor and, apart from not being able to say what produces such complicated bodies as tannin and the essential oil in the leaf, we are at present unable to state definitely how any change in the content of the simpler products of the leaf—nitrogen, phosphorus and potash—may be effected.

Much work has been done on the effect of manures on the constitution of plants other than tea, and it has been shown by Schreiner and Skinner (*U. S. Dept. Agric. Bull., No. 70*) that each constituent of the perfect plant food mixture is absorbed by the plant in such a quantity that the balance of the original mixture is undisturbed. If any one of the constituents of the ideal mixture is increased, then the plant takes up more of this constituent and tends to reduce the residue to the perfect ratio. Any excess of one constituent is followed by an increased proportion in the plant. This has been shown with water cultures where the conditions are of the simplest.

Most of the work connected with the effect of manures on the constitution of plants growing in soil has been done on

certain plant organs, more particularly with seeds. In these cases the variations were small and sometimes no greater than the variation shown by individual plants.

In tea we are concerned with the analysis of the flushing leaves of the bush, and this makes the problem different from that connected with an ultimate organ of a plant. The leaf is merely the seat of manufacture of the plant's food, and as such it should respond to small variations in the composition of the soil solution.

The work in connection with this question has been carried out during the year 1920 on tea seedlings and tea bushes.

Sand cultures.—The value of pot culture experiments has long been recognised by agricultural chemists, but the facts can only be used in connection with field work when local conditions are perfectly understood. With a sand culture the medium, although somewhat resembling a soil in its surface effect, is, from the chemical point of view, quite inert. The question of soil toxins, either organic or inorganic, does not arise. It has also been suggested that "live" soil contains substances with similar functions to those of vitamins, substances occurring in small quantities in fresh food, in the absence of which life cannot be supported no matter what the content of the food substance may be in carbohydrates, proteins, etc. Such substances, of course, are absent from pure sand.

Practically all the Assam soils are what is loosely termed "acidic," which property brings about unexpected results on the addition of manures. On some soils potash manures have a depressing effect on the crop, while phosphatic manures show an increase which is much greater than would be expected if the manure merely acted as a food. On other soils which are apparently the same, just the reverse action has been noticed. When we deal with sand cultures these questions, which are of much importance in the field, do not arise.

Betjan seeds were germinated on 3rd December, 1919, and were then transferred to acid-washed, ignited sand. On 15th

March, 1920, when the seedlings were well established, the remainder of the cotyledons was removed and nutrient solutions added. The strength of the solution was based on one suggested by Knoop :—

4 parts calcium nitrate, $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$
 1 part potassium nitrate, KNO_3
 1 „ „ dihydrogen phosphate, KH_2PO_4
 1 „ magnesium sulphate, $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$
 1 „ ferric chloride, FeCl_3

added as 0.1% solution.

If the moisture is 10% the sand gives the following analysis:—

Nitrogen as nitrate = 8.7 pts. per million.
 Water available potash = 0.0012%.
 Water available phosphoric acid = 0.00077%.
 Water available magnesia = 0.00024%.

These figures are comparable with the values found in our soils.

For simplicity in calculation the solutions were made up from sodium nitrate, superphosphate, potassium and magnesium sulphate so that the same concentration of essential constituents as suggested by Knoop was obtained.

Twelve sets of experiments were started. In each set were nine seedlings and the ratio of the three chief constituents—nitrogen, phosphorus and potash—was varied.

Each day the cultures were weighed and enough distilled water added to make the content up to 10%. After a period of nine weeks differences became apparent in the seedlings. Those receiving a high percentage of nitrogen were badly attacked by Brown blight. As the percentage of nitrogen decreased the colour of the leaves became lighter till with a high percentage of phosphate the colour was a light yellow.

On 6th August fresh manure was added and the moisture content brought from 10 to 15%. The seedlings at once became

stronger and those which were banjhi began to send out new shoots. This fact is interesting for, from theoretical considerations, the lower water content should be the optimum.

On 15th October the seedlings were uprooted, dried and analysed for nitrogen, potash and phosphoric acid. The table below gives the result of these analyses together with the number of plants alive when the experiment finished and the total weight of the dried plants.

The results obtained may be summarised as follows :—

- (1) *Growth*.—The most vigorous seedlings, as judged by the weight of the crop, are those receiving manures rich in potash. The least vigorous are those receiving a manure rich in nitrogen.
- (2) *Nitrogen Content*.—There is apparently no relationship between the nitrogen content of the whole plant and that of the manure. The richer the manure is in nitrogen the more liable is the plant to Brown blight attack.
- (3) *Phosphatic Content*.—As the phosphatic content of the manure increases, so does that of the seedling.
- (4) *Potash Content*.—The relationship between the potash content of the manure and that of the plant is not so simple as that connected with phosphates. The manure giving the highest potash content in the seedling is one containing a high potash and phosphate content and a low proportion of nitrogen. More work is necessary before anything definite can be stated in this connection.

During the year 1921 fresh seedlings will be grown and treated with various manures.

Experiments with the Leaves of Tea Bushes :—Whereas with experiments on tea seedlings infinite care and trouble are necessary, work on bushes in the field is comparatively simple. A plot of 252 bushes was used for the experiments described below.

Between each treated bush and each check bush was one untouched bush. Nitrogen was added in the form of dried blood, potash as chloride and phosphate as superphosphate. The total manure added to each bush was based on the figure 90 lbs. per acre calculated on potash as K_2O , phosphate as P_2O_5 , and nitrogen as N. Every possible variation containing two and three manures was employed, the amount of each constituent varying from 15 to 75 lbs. per acre. In all, twenty-five different mixtures were added.

Every seven days throughout the flushing period, leaves were plucked and dried. Regular plucking, two leaves and a bud was observed throughout. At the end of the season (1919) the analyses were made. In April, 1920, manures were added to the plots as before and the leaves were plucked throughout the season. The analyses will again be made.

The following deductions have been made:—

(a) *Nitrogen*.—The variation in the nitrogen content of different leaves is very great. It is well known that even in small plots, differences due to soil irregularities are greater than those due to manurial treatment. Only after comparing each value with that of the corresponding values of the check bushes can any relationship between manurial treatment and leaf constitution be observed.

The manures richest in potash produce leaves poorest in nitrogen. If excessive nitrogen renders a bush liable to blight attack, it seems highly probable that the beneficial effect of potash manures may depend on their power of reducing the nitrogen content.

In all cases except four, manuring appears to have increased the percentage of nitrogen. In two cases, both receiving manures rich in potash, there has been no change. But the differences everywhere are seen to be extremely small and almost negligible when the variation between individual bushes is considered. Probably now that a nitrogen value has been obtained for each

bush, the second year's manuring will show a change compared with last year's individual value.

(b) *Phosphates*.—There is apparently no definite relationship so far between phosphatic content of the manure and the leaf composition.

(c) *Potash*.—No relationship between the potash content of the manures and that of the leaf can be seen after the first year's manuring.

Recent work at Pusa has shown that the nitrogen content of rice may be doubled by the addition of large doses—160 lbs. N per acre—of manure. Such quantities are of course impracticable in the field. Smaller doses have practically no effect on the constitution of the rice seed. It has been shown that the constitution of the mustard plant is not affected by manuring with such small doses as 15 lbs. per acre.

The problem with the tea bush is different in that we are dealing with a perennial, so that the effect of manure is cumulative. In many cases it will probably take several seasons to bring about any definite alteration in the constitution of the leaf by manuring.

TABLE SHOWING THE EFFECT OF MANURES ON THE CONSTITUTION OF
THE TEA SEEDLING.

THE MANURIAL RATIO 3/3/3 REPRESENTS THE IDEAL MANURE AS SUGGESTED BY KNOOP.

Nine Plants in Original Experiments.

Manurial Ratio Potash/Phosphorus Nitrogen.		1/7/1	1/6/2	1/1/7	2/5/2	3/3/3	3/1/5	4/4/1	4/1/4	5/3/1	6/2/1	6/1/2	7/1/1
Total weight of seedlings in gms.	...	2.88	3.95	1.13	3.65	2.64	1.70	3.37	1.64	2.77	4.52	4.27	5.35
Final number of seedlings...	...	6	8	3	7	5	3	7	3	5	7	8	9
Average weight of seedlings in gms.	...	0.48	0.49	0.38	0.52	0.53	0.57	0.48	0.55	0.55	0.65	0.53	0.59
Moisture	...	4.32	6.51	...	4.82	6.06	8.68	6.92	...	4.78	4.38	5.44	5.18
Ash per cent. (on dry material)	...	6.67	6.62	...	7.39	6.75	6.17	6.84	...	7.59	7.37	7.07	8.54
Potash per cent.	...	37.19	37.99	...	34.58	35.99	44.32	41.01	...	38.78	38.02	37.39	37.70
Phosphate per cent.	...	12.70	11.80	...	8.84	7.12	7.07	10.73	...	6.63	6.52	5.51	4.38
Nitrogen per cent.	...	2.28	2.43	2.57	2.55	2.67	...	2.82	2.82	2.29	2.44	2.28	2.56

C. R. H.

OBSERVATIONS ON THE CLIMATE AND CROP OF SEASONS 1918, 1919 AND 1920.

The past three seasons in the tea districts of Assam have not been at all normal. The year 1918 is notable on account of the heavy and continuous rainfall. For days together the drains at Tocklai were full and the result of such water-logging is not only reflected by the leaf yield at the time but also by its bad effect on the general health of the bush in the ensuing dry season. The total rainfall registered at Tocklai for this year was 96·94 inches.

In the following year, 1919, the rainfall was only 75·08 inches. This would have been sufficient if it had been well distributed, but 45 inches fell on 25 days.

During the past season the rainfall only amounted to 67·55 inches. Although this is below the average, the distribution up to October was so good that the soil was in about optimum condition almost the whole time. From October onwards the rainfall was deficient and plucking ceased before the end of November.

Below is a table showing the monthly rainfall and the number of wet days in each month recorded at Tocklai for the last three years.

TABLE.

MONTHS.	Rainfall in ins.			No. of days on which rain fell		
	1918	1919	1920	1918	1919	1920
January	0·12	0·28	0·63	1	2	2
February	1·26	0·97	2·73	4	5	8
March	6·37	0·75	6·15	16	3	14
April	5·91	7·41	9·08	11	8	13
May	15·42	6·57	6·73	13	11	11
June	14·62	22·09	9·89	19	18	19
July	18·20	16·37	14·18	20	21	18
August	13·48	10·71	9·22	18	13	20
September	12·44	9·59	6·17	15	18	15
October	2·42	9·40	2·47	4	10	9
November	0·40	0·42	0·20	1	4	2
December	nil	0·11	0·10	nil	2	2

Attached are graphs showing the mean weekly temperatures and the weekly crop and the rainfall for the three seasons.

The monsoon change is seen about halfway through June. Before this period, the prevailing winds have come from the central Asiatic plateau to the North of Assam and have been cold and dry. Winds bringing rain during the critical months of February, March and April are accompanied by a rise in temperature and hence must have originated in the South. After the South-West monsoon has broken, rain is accompanied by a fall in temperature.

The crop was plucked from the Tocklai clearance which is an area of 3 acres planted with eight different jats of tea—Manipuri, Burma, Kalline, China, Singlo, Kharikatia, Panighat, and Betjan. The tea was put out at the end of 1914, collar pruned in 1916, and then left till it was cut back in 1918 to 6 inches. In 1919 half was cut back to 10 inches and the other half skiffed. The total crop for the three years 1918, 1919 and 1920 was 7,069, 3,825 and 7,790 lbs. respectively. The different treatment received by the bushes is the chief factor accounting for the difference in crop from year to year, and in comparing the curves and correlating them with the rainfall and temperature, the form, and not the magnitude, should be taken into account.

Turning first to the diagram for the season 1918, it will be seen at once that rainfall was at no time lacking. The time of plucking at Tocklai during this season was different from that in the seasons following, when a regular pluck was made every seven days. The curve for the 1918 crop shows six distinct points of great output. There is one in May, one in June, one in July, overshadowed by a greater one in August, one in September and the final one at the end of October. These maxima may be taken to represent six flushings during the season. At each flush the bushes were plucked "to the gums" and the result is seen by the falling off in crop in the following week. In July and August the bushes are flushing most vigorously. Experiments at Tocklai during this period have shown that the regeneration time (i. e. the time required for

the development of a fresh flush) is about thirty days. Later on, the period increases and the autumn flush takes six weeks to mature. This slower rate of growth probably accounts for the improved flavour of the late teas.

In 1919, the cold weather drought continued well into April and this accounted for the late start made by the bushes. To the end of July the increase in leaf continued and then the crop fell off. The cause of this was undoubtedly the dryness of the atmosphere at this time. The normal mean temperature during the hot months in Assam is about 82.5° F. A rise in the mean is almost invariably followed by a fall in crop, not because such a temperature is unfavourable to leaf growth, but because the humidity of the atmosphere invariably falls from about 94 which is the normal to 75 in this particular case. The drier the atmosphere becomes, the easier is it for the bush to carry out its normal transpiration. When the atmosphere becomes very moist this action can only be carried on by increasing the leaf area. During the period we are considering a fair quantity of rain fell, but mostly at night, so that its full benefit in raising the humidity was lost. The heavy crops obtained at the end of the season were no doubt due to the good rains which prevailed in October, for the results of any peculiarity in the weather are usually most apparent about three weeks after such weather.

Turning now to the 1920 chart, it is at once apparent that the beginning of the season, while more favourable than that of the previous year, still had its drawbacks. Up to the middle of May the rainfall had been too heavy and continuous and the temperature too low for this period of the year and the soil was becoming water-logged. The dry weeks ending May 23rd, 30th and June 6th, put the soil into better condition and the result is seen in the rapid increase in crop. At the same time, the dryness and hot sun considerably increased the attack of Brown blight which became serious till the rains in the latter part of June modified climatic conditions.

One of the highest yields was obtained on June 20th. During this week, the skiffed dark-leaved varieties gave their

greatest yields. The other point notable for a good yield is that of October 17th. In this week the skiffed light-leaved varieties gave their best yields and the cut-back tea had come into full bearing. The depression starting during the week ending August 8th is no doubt the aftermath of the dry week in July which was accompanied by a period of low humidity. The heavy rainfall in the two weeks following, coming chiefly at night, did not raise the humidity as much as might be expected.

Although plucking ceased practically everywhere, by arrangement, on November 15th, it was carried on at Tocklai till the end of the real season which finished on November 30th. The early close was due to the irregularity of the rainfall after September 19th and to the drought which started on October 13th, twenty days earlier than in the previous year.

C. R. H.

TOCKLAI CLEARANCE.

Object and Plan : The object of this clearance is to show good specimens of some of the most common varieties of tea planted in North-East India. It cannot strictly be described as a trial of the various "jats" since there is only one plot of each, and in this district soil often varies so greatly within a small area that results from a single plot can never be depended on with any degree of accuracy. In this case the variation in soil over the whole area is probably less than usual. The comparatively heavy manuring has also tended to make the soil over the whole clearance more even. The analyses given below show the variation that actually occurs.

	Manipuri ^o plot top-soil.	Kharikatea plot top-soil.	Betjan plot top-soil.	Betjan plot sub-soil.
Coarse sand	4.70	5.94	5.97	4.86
Fine sand	63.38	63.28	68.37	54.50
Silt	12.66	12.27	7.66	19.02
Fine silt	11.29	9.17	10.19	9.02
Clay	3.99	5.93	4.28	8.66
Loss on ignition (organic matter) ...	3.35	3.06	2.92	1.98
Total nitrogen	0.10	0.12	0.115	0.078
Available potash	0.007	0.008	0.008	0.007
Available phosphoric acid	0.005	0.006	0.007	0.002

^o This analysis was made in 1915, the others in 1920. It is probable that in the interval the Manipuri plot has improved.

A crop of cowpeas was weighed before burial in 1919. The crop from the Manipuri plot at the south end of the clearance was $4\frac{1}{2}$ tons per acre and the weight obtained fell off fairly evenly

from south to north till only 4 tons per acre were obtained from the Panighat plot. The growth of Arhar in 1920, although not weighed, confirmed the fact that fertility fell off fairly evenly from south to north.

After 1919 it was decided also to use these plots for a trial of unpruned tea, the intention being to leave half of each plot unpruned every other year.

Pruning : The pruning has been practically that which was considered orthodox where it is desired to produce wide bushes early.

1916. Collar pruned in November, after 2 years in the soil or 3 years from seed.

Average yield for 6 plots 1917 2.40 mds. pucca tea per acre.

In the case of the Betjan and Panighat where planting was a year later (at 6 months old), collar pruning was done in August, 1917, after 2 years in the soil, or at $2\frac{1}{2}$ years from seed.

Average yield of 2 plots in 1918 5.29 mds. pucca tea per acre.

The gain from early collar pruning is obvious, and the subsequent history of the plots shows that the bushes suffered no harm.

1917. Unpruned.

1918. Average yield from 6 plots planted in 1914 8.18 mds. per acre.

Cut down to 6" in December.

This is lower than such cutting is usually performed. The idea is to obtain a small number of stronger shoots with a wide spread from near the ground.

1919. Average yield from 6 plots planted December 1914 4.09 mds.

Average yields from 2 plots planted July 1915
3.95 mds.

The eight plots from 1919 onwards may be considered to have become approximately equal, except in respect of jat.

At this point it was decided to leave half on each plot unpruned every other year, while the other half should be pruned annually.

Therefore one-half was pruned to 4" new wood (10" from ground), all snags were cut out, and "spacing out" was also attended to. The other half still carried many shoots dying back from brown blight. It was therefore lightly skiffed over the top to remove these shoots, instead of being absolutely unpruned.

1920. Average yield from pruned 8 plots	} mean
4.77 mds.	
Average yield from skiffed 8 plots	
11.63 mds.	8.2 mds.

Both styles of pruning had produced a good "spread," but the lower (2 years old) wood is on the whole stronger and cleaner on the "skiffed" areas than on the "pruned" area. This is particularly noticeable on the Khari-katia and Singlo plots where, also, one-year wood on many bushes is distinctly poor.

In December 1920 the half which had been "skiffed" was cut down to 10" from the ground, and the half which had been cut down to 10" the previous year was cut across at 14" (leaving 4" new wood).

In both cases spacing out was attended to, but all strong shoots (whether "outsides" or "centres") for which there was sufficient room were left.

It is estimated that the 11" pruning on one-year wood will in 1921 give very much more leaf than the 10" pruning on two year wood, but the difference is not expected to equal the lead of 7 mds. per acre held by the "skiffed tea" in 1920.

On the whole, therefore, the result of this trial, so far as it has gone, is in favour of pruning young tea only every other year. It is considered however that 1920 was favourable to such pruning. The early part of the year was particularly favourable and there was at no time anything approaching drought. The early close to the season, also, stopped flushing at a time when the pruned tea was yielding heavily while the skiffed tea was distinctly falling off.

Manuring : The manuring represents no kind of trial, and was simply that thought desirable at the time. It is, therefore, simply set down for record.

Before planting 10 mds. slaked lime per acre.

20 tons cattle manure per acre.

Boga medeloa sown broadcast and crop ploughed in, in autumn.

1915. Boga medeloa planted between alternate lines of tea, and lopped at intervals.

1916. Sterilized animal meal 200 lbs. per acre.

Superphosphate ... 100 lbs. " "

Prunings and Boga medeloa buried in trenches 18" deep between alternate lines of tea.

1917. 2 oz. sulphate of ammonia and 2 oz. superphosphate to weakly bushes only.

1918. Slaked lime ... 10 mds. per acre.

1919. I. O. P. Oilcake ... 200 lbs. per acre.

Sulphate of ammonia ... 50 " " "

Bone Dust ... 200 " " "

Cowpeas hoed in after six week's growth.

In August, on account of Brown blight, 1 oz. nitrate of potash per bush.

Following this treatment, the bushes, helped by rainy weather, made fine new growth from below the diseased shoots.

1920. Fish manure ... $3\frac{1}{2}$ mds. per acre (broadcast)
 Nitrate of potash ... $\frac{1}{2}$ oz. per bush (forked in)
 Arhar sown in alternate lines, lopped three times during the season up the sides, and tops buried with prunings in 18" trenches in December.

1921. No manure will be applied.

Plucking : The system of plucking used has been practically that followed in the immediate district.

In each case after cutting down, plucking was commenced at 27" from the ground.

In 1920 the skiffed tea made a very early start and had grown about 6" from the skiffed surface before plucking commenced.

In 1917, 1918, and 1919 the plucking system took all the ready leaf above the original plucking level, and was so strictly applied that the bushes even when unpruned maintained a flat surface. In these years plucking was to the "janam" right from the beginning of the season, any shoot that grew above the level surface being broken back.

In 1920, after July, one leaf above the janam was left, and no breaking back was allowed. The object of this change was to see if, with regular weekly plucking, the flat bush could be maintained. The photograph taken at the end of September shows that the level was very fairly kept, only a few shoots getting away.

In every case plucking was strictly limited to two leaves and a bud. The percentage of moisture in the leaf, as weighed, was determined weekly, and varied from 75% on a hot clear day to 79% on a rainy day, with an average for the whole season of 76.2%. Since good pucca tea contains about 7% of moisture, the ratio of pucca tea to green leaf therefore works out at

25.5% of weight of green leaf weight of pucca tea, or very nearly :—

pucca tea— $\frac{1}{4}$ green leaf

and in the yields quoted, the weight of pucca tea has been taken as one-quarter of the green leaf, which was weighed accurately to a quarter of a pound.

Yield in maunds of pucca tea per acre.

	1917.	1918.	1919.	1920.*	Total in 4 years.
Manipuri ...	2.56	9.06	4.59	7.57	23.78
Burmah ...	2.89	9.00	4.71	9.21	25.72
Kalliae ...	2.53	9.34	4.38	8.23	24.48
China ...	2.05	7.67	4.26	7.45	21.43
Kharikatia ...	2.62	7.95	3.66	7.95	22.18
Singlo ...	1.76	6.05	2.77	7.11	17.69
Botjan ...	.....	5.64	4.35	10.00	.....
Panighat ...	.....	4.95	3.55	8.17	.....

* Yield quoted is the average yield from the skiffed and cut-back plots.

Varieties : Taking into consideration that the Kharikatia plots are on rather poorer soil than the Manipuri and Burmah plots, and that the original planting of the Singlo plot was bad on account of a poor nursery, the yields obtained do give some indication of the yielding capacity of the various jats.

The plots include : Dark-leaved indigenous 4 plots.
 Light-leaved „ 3 plots.
 China 1 plot.

The *China* has done surprisingly well.

In appearance the majority of the bushes resemble a good or fair *hybrid* rather than the stunted small-leaved bushes now seen on the average very old China sections of many gardens. However unless it can be shown that the quality of the tea from China is distinctly superior to that from indigenous tea, it is clear that planters have acted rightly in ceasing to plant the China bush. It yields a large number of shoots, but their small size makes the weight of leaf obtained small, and plucking is relatively expensive.

At Tocklai it has been found that the China bush is most liable to attack by red spider and red rust, but remains almost free from brown blight.

Contrary to the usual belief it has been found at Tocklai that China does not respond well to hard pruning.

The relative yields from "skiffed" tea compared to tea cut down to 10" are instructive.

	China.	Light leaf indigenous.	Dark leaf indigenous.
Skiffed	10.88 mds.	11.91 mds.	11.62 mds.
Cut down to 10"	4.02 mds.	4.80 mds.	4.93 mds.
Ratio $\frac{\text{skiffed}}{\text{cut down}}$	2.71	2.48	2.37

In this case the China has responded distinctly worse to the heavier pruning than the indigenous varieties. Many bushes came away after pruning very poorly indeed.

The great difficulty with China is its habit of growing flowers and seed. Branches carrying flower and seed will not give leaf. It appears preferable, however, to stimulate growth, by closer plucking and light pruning accompanied by more severe cleaning out, rather than by cutting back more frequently or more heavily.

The dark-leaved indigenous varieties have on the whole shown themselves more hardy, less liable to leaf-diseases, and more easily established than the light-leaved varieties. The leaf generally is smaller and therefore more expensive to pluck. The dark-leaved varieties produce thicker wood; but whereas any thin wood on a dark variety will give little leaf, thin wood will give fair flushes on a light-leaved plant.

The dark-leaf varieties come away earlier in the season, but give relatively less than the light leaf towards the latter part of the season.

For example, in 1920 although the Betjan plot (the best light leaf) gave more leaf over the whole season than the Burmah (best dark leaf) the yields up to the end of May were :—

	Dark Burmah	Betjan
Skiffed plot	... 94 lbs.	60 lbs.
Cut back	... 8 lbs.	3½ lbs.

Dark Burmah : A very hardy free-growing large-leaved plant, which has consistently remained comparatively free from blight and yielded well in all seasons.

This plot is more even than any other on the station. A new clearance of this variety put out in November 1920 at Bor-bhetta is now (January) looking splendid and is without a vacancy in spite of the dry weather, whereas a light leaved variety planted alongside is looking very bad, is badly attacked by red spider and has suffered many deaths.

“Black Burmah” can be confidently recommended even for the poorest soil, particularly in a district liable to drought.

Since this seed has to be collected in hill jungles, transport difficulties very often lead to such late delivery, that nurseries are not so good as those from early-planted seed. For this reason it is probable that a “once-removed” Black Burmah would be more reliable, but has not been tried at Tocklai.

Dark Manipuri greatly resembles Burmah, but contains a fair percentage of bushes carrying broad light leaves, which are less hardy and appear not to yield so well as the dark-leaved.

Previous to 1920 the yield had been practically as good as the Burmah. No reason can be assigned for the comparative falling off in 1920. This plot will be required for buildings next year so that it will not be possible to decide whether the falling off is permanent.

Kalline : Also a fine dark hardy plant, but the plot contains too many bushes almost “hybrid” in appearance. Yield has been rather less than from the Burmah.

Panighat : A dark-leaved variety showing generally smaller leaves than the Burmah and Manipuri. It is possible that the plants for seed bushes were not very carefully selected. This plot, however, has remained more free from blights than any of the others and always looks very healthy. The plot is at the extremity of the more infertile end of the clearance.

Kharikatia : This is a Singlo once removed, and represents the type of light-leaved indigenous tea most commonly found in Assam. The leaf of this type is characterised by its great length, narrowness, and very long pointed tip. In the early part of the season, the plant shows a fine large healthy-looking leaf not much lighter than Manipuri, but as the season advances plucking bushes show smaller leaves distinctly lighter in colour, while in the cold weather the leaf becomes almost yellow, and as at Tocklai and Borbhetta it is always attacked by red spider, it presents a very poor appearance at this season. It has also been observed to be more liable to fungus diseases of the leaf than are dark varieties, and more sensitive to abnormal soil conditions such as water-logging and drought. It is undoubtedly more difficult to establish.

On the other hand it produces comparatively large shoots, and appears capable of yielding better than dark-leaved varieties on really good soil with favourable weather ; and it has been observed on many gardens that this and similar varieties do very well when they have become well established.

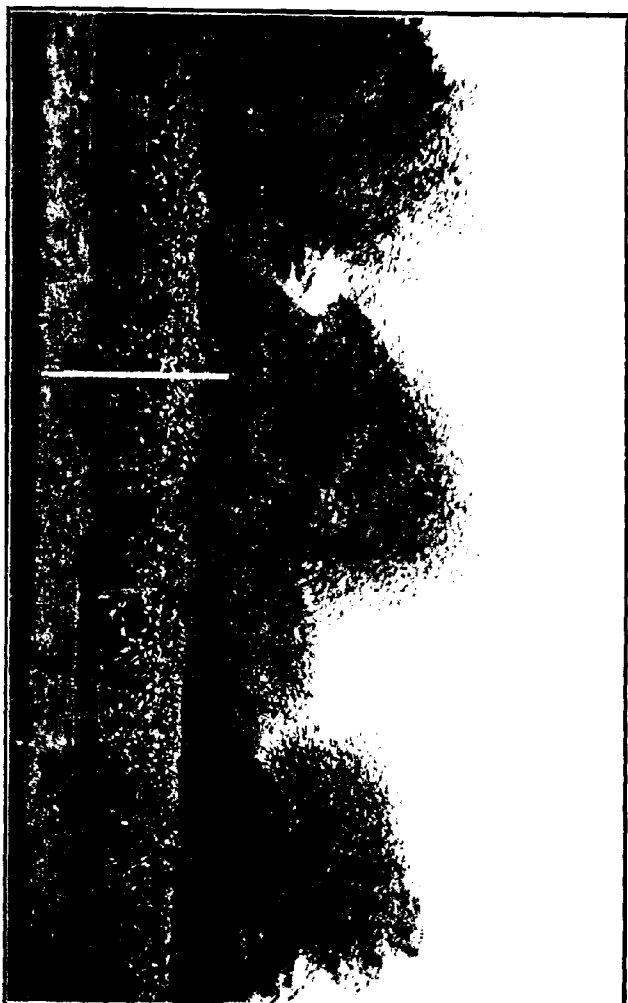
Singlo Hill : This particular plot on account of a bad nursery is still very backward and contains many infillings. It is, of course, of the same type as Kharikatia, and the same remarks apply.

Betjan : It is also a light-leaved Assam indigenous variety, but quite different in appearance from those of the Singlo type. Its leaf is very broad, instead of very narrow, rather resembling light-leaved Manipuri. It is darker than the Singlo type of leaf, and the leaf areas between the veins stand out as if embossed. Betjan, like other light-leaved varieties, is very liable to leaf diseases, particularly brown blight, but in spite of

this grows remarkably vigorously, and yields extremely well. In 1920, which was on the whole a season favourable to delicate jats, it proved the heaviest yielder on the station. The skiffed area in 1920 (at 5 years from seed) yielded over 14 mds. pucca tea per acre.

A clearance of this variety has also done relatively well on the poor, unmanured soil at Borbhetta. It is a type not commonly seen. Goipani and Tingamira (light leaf) are stated to have originated from Betjan seed, and are certainly of a similar type.

H. R. C.



BURMA PLOT, SEPTEMBER 27th 1920, after skiffing.



BURMA PLOT, JANUARY 1921.

Foreground, pruned to 14" on 1 year wood.
Background, pruned to 10" on 2 year wood.



MANIPURI PLOT, SEPTEMBER 27th 1920.

Foreground, after pruning to 10".

Background, (where bushes touch) after skiffing.



SINGLO PLOT, JANUARY 1921.

On left, pruned to 14" on 1 year wood.

On right, pruned to 10" on 2 year wood.

Note comparative thickness of lower wood.



BETJAN PLOT, SEPTEMBER 27th 1920.

Foreground, after pruning to 10%.

Background, (behind boy) after skiffing.



BETJAN PLOT, JANUARY 1921.

Foreground, pruned to 16" on 2 year wood.
Background, pruned to 14" on 1 year wood.

